Digitized by the Internet Archive
in 2016 with funding from
South African National Biodiversity Institute Libraries

https://archive.org/details/journalofsouthaf32unse

MARY GUNN LIBRARY
NATIONAL BOTANICAL INSTITUTE
PRIVATE BAG X 101
PRETORIA 0001
REPUBLIC OF SOUTH AFRICA

NAVORSINGSINSTITUUT VIR PLANTKUNDE
BIBLIOTEEK.

25. 11. 1968

CATALOGUE NO. ....
LIBRARY
BOTANICAL RESEARCH INSTITUTE.

MARY GUNN LIBRARY
0000032258
South African

JOURNAL

OF

SOUTH AFRICAN BOTANY

VOLUME 32 1966

Published under the Authority of the Trustees of the

NATIONAL BOTANIC GARDENS OF SOUTH AFRICA

Kirstenbosch, Newlands, Cape Province

EDITOR

H. B. RYCROFT,

M.Sc. (S.Af.), B.Sc. For. (Stell.), Ph.D. (Cape Town), F.L.S., F.R.S. (S.Af.)

DIRECTOR OF THE NATIONAL BOTANIC GARDENS OF SOUTH AFRICA

HAROLD PEARSON PROFESSOR OF BOTANY IN THE UNIVERSITY OF CAPE TOWN

NAVORSINGSINSTITUUT VIR PLANTKUNDE
BIBLIOTEEK:

CATALOGUE NO. ....
LIBRARY
BOTANICAL RESEARCH INSTITUTE.

JOURNAL OF SOUTH AFRICAN BOTANY

VOLUME 32 1966

CONTENTS

PAGE

PLANT ECOLOGY OF THE GRAHAMSTOWN NATURE RESERVE: II. SOME EFFECTS OF BURNING. A. R. H. Martin, M.A. (Camb.), Ph.D. (Lond.) 1

STAPELIEAE FROM SOUTH TROPICAL AFRICA: II. L. C. Leach and D. C. H. Plowes 41

A NEW POISONOUS AGARIC FROM THE CAPE PENINSULA. Edith L. Stephens, B.A. (Cape Town) 61

A DEFINITION AND NAME FOR AN EASTERN CAPE CRINUM. I. C. Verdoorn 67

HAEMANTHUS CANALICULATUS, A NEW FIRE-LILY FROM THE WESTERN CAPE PROVINCE. M. R. Levyns, B.A. (Cape), D.Sc. (Cape Town), F.R.S.S.Af. 73

A PAPER CHROMATOGRAPHIC SURVEY OF FREE AMINO ACIDS AND RELATED COMPOUNDS IN THE PROTEACEAE. J. van Staden, M.Sc. (Stell.) .. 77

STUDIES IN STREPTOCARPUS. O. M. Hilliard, M.Sc. (Natal) 87

NOTES ON MESEMBRYANTHEMUM AND ALLIED GENERA. H. M. L. Bolus, Hon. D.Sc. (Stell.), F.R.S.S.Af. 125

STUDIES IN CYPERACEAE IN SOUTHERN AFRICA: III. Kathleen D. Gordon-Gray, M.Sc. (S.Af.), Ph.D. (Natal) 129

STUDIES IN CYPERACEAE IN SOUTHERN AFRICA: IV. Kathleen D. Gordon-Gray, M.Sc. (S.Af.), Ph.D. (Natal) 141

STUDIES IN STREPTOCARPUS: II. O. M. Hilliard, M.Sc. (Natal) 153

EUPHORBIA SPECIES FROM THE ZAMBESIACA AREA: V. L. C. Leach .. 173

EFFECTS OF MOLYBDENUM AND DIFFERENT SOURCES OF NITROGEN ON THE GROWTH AND CHEMICAL COMPOSITION OF *DIGITARIA SMUTSII* STENT. J. A. de Bruyn, M.Sc. (S.Af.), Ph. D. (Chicago) and J. Aalbers, Hons. B.Sc. (Stell.) 183

A NEW STAPELIAD FROM S.W. AFRICA. J. J. Lavranos 195

NOTES ON MESEMBRYANTHEMUM AND ALLIED GENERA. H. M. L. Bolus, Hon. D.Sc. (Stell.), F.R.S.S.Af. 201

PAGE

NOTES ON *CONOPHYTUM FICIFORME* (HAW.) N. E. BR. AND *C. PLACITUM* (N. E. BR.) N. E. BR. R. C. Littlewood 205

NOTES ON THE GENUS DELOSPERMA (*MESEMBRIAE*) 209

CYTOGENETIC STUDIES IN THE GENUS ORNITHOGALUM L.: II. KARYOTYPE ANALYSES IN SOME BIOTYPES OF *O. CONICUM* JACQ., *O. LACTEUM* JACQ. AND *O. THYRSOIDES* JACQ. R. de V. Pienaar, Ph.D. (Witwatersrand) and T. J. Roos, M.Sc. (Stell.) 211

NOTES ON MESEMBRYANTHEMUM AND ALLIED GENERA. H. M. L. Bolus, Hon. D.Sc. (Stell.), F.R.S.S.Af. 229

A NEW SPECIES OF CONOPHYTUM. R. C. Littlewood 235

NOTES ON *ERICA VIRIDIFLORA* AND THE DESCRIPTION OF A NEW ERICA SPECIES. Col. H. A. Baker, O.B.E., M.C. 237

OBSERVATIONS ON THE TEMPERATE AFFINITIES OF THE VEGETATION OF HANGKLIP MOUNTAIN NEAR QUEENSTOWN, C.P. B. R. Roberts, M.Sc. (Agric.) (Natal) 243

CYTOGENETIC STUDIES IN THE GENUS ORNITHOGALUM L.: III. MEIOTIC ANALYSIS OF SOME INTERSPECIFIC HYBRIDS OF *O. CONICUM* JACQ., AND *O. LACTEUM* JACQ. R. de V. Pienaar, Ph.D. (Witwatersrand) and T. J. Roos, M.Sc. (Stell.) 261

STUDIES IN STREPTOCARPUS: III. THE STREPTACARPUS FANNINIAE ALLIANCE. O. M. Hilliard, Ph.D. (Natal) 273

STUDIES IN THE GERMINATION OF SEED OF PROTEACEAE. J. van Staden, M.Sc. (Stell.) 291

STAPELIEAE FROM SOUTH TROPICAL AFRICA: III. L. C. Leach and D. C. H. Plowes 299

SOME NOTES ON THE INTERNAL ANATOMY OF LITHOPS: I. Chester B. Dugdale, A. B. (Drew), M.Ed. (Columbia) 305

EFFECTS OF BORON, MANGANESE, COPPER AND ZINC UPON THE GROWTH OF *SETARIA SPHACELATA*. J. A. de Bruyn, M.Sc. (S.Af.), Ph.D. (Chicago) and Wayne G. McIlrath, M.S., Ph.D. (Iowa) 313

CYTOGENETIC STUDIES IN THE GENUS ORNITHOGALUM L.: IV. THE CYTOGENETICS OF INTER- AND INTRASPECIFIC CROSSES INVOLVING *O. THYRSOIDES* JACQ. AND *O. LACTEUM* JACQ. T. J. Roos, M.Sc. (Stell.) and R. de V. Pienaar, Ph.D. (Witwatersrand) 325

NOTES ON MESEMBRYANTHEMUM AND ALLIED GENERA. H. M. L. Bolus, Hon. D.Sc. (Stell.), F.R.S.S.Af. 335

NOTES ON THE GENUS DELOSPERMA (*MESEMBRIAE*). M. Lavis .. 341

ANATOMIE VAN DIE STINGELS VAN *PROTEA REPENS* (L.) L. EN *LEUCADENDRON ADSCENDENS* R. BR.: II. ANATOMIE VAN DIE STINGELS. Carina Visser, M.Sc. (Stell.) 347

C.T.P. LTD.

JOURNAL
OF
SOUTH AFRICAN BOTANY
VOL. 32

Published: 1st January, 1966

THE PLANT ECOLOGY OF THE GRAHAMSTOWN NATURE RESERVE:

II. SOME EFFECTS OF BURNING

A. R. H. Martin
(*University of Sydney, N.S.W., Australia*)

Introduction

In part I of this study (Martin 1964) a general account of the vegetation of the Reserve has described the domination of the area by nanophanerophyte (ericoid) heath, temperate tussock grassland and temperate evergreen rain-forest formations.

In an attempt to preserve part of this flora near Grahamstown, the Reserve has been cleared, in the main, of exotics such as Pines, Australian Wattles, *Hakea* and Bluegum, fenced and surrounded by firebreaks 12 ft. wide. These firebreaks have not prevented veld fires entering the Reserve. One such fire occurred in August, 1948, during a period of intense drought, which persisted until 1949. A comparison of the phenological response of species on burnt and unburnt ericoid heath and grassland was commenced, in order to throw some light on the secondary plant succession. These observations were supplemented by the experimental burning of small plots to study the physical conditions during fire and the differences observable after burning when the composition of the vegetation was more accurately known.

During these studies a second fire, in August, 1951, burned a good deal of the heath missed by the earlier fire. This burning was followed by a wet spring and considerable differences in response of some species were noticed. Observations, including some soil studies, were continued through 1952.

In 1955 a very severe fire destroyed almost all the remaining heath in the Reserve together with the regenerative growth in the previously burned areas, and so altered the conditions of succession that the original objects of the investigation were at least partly nullified. Nonetheless, observation till September, 1956, gave some additional information and the work as a whole, though somewhat incomplete, forms a report on the state of the Reserve and a basis for more detailed research.

THE REGENERATION AND FLOWERING OF SPECIES IN ERICOID HEATH FOLLOWING FIRES

Observations of vegetative regeneration and flowering times, and qualitative estimates of flowering abundance were made after each burning. Owing to some contrasts in regenerative behaviour between dry and moist conditions, the periods of observation are best considered separately.

(*a*) The Fire of 1948.

(1) PHENOLOGY.

Phenological observations made between 1948 and 1951 suggested that regenerating plants could be placed in five groups (Table 1).

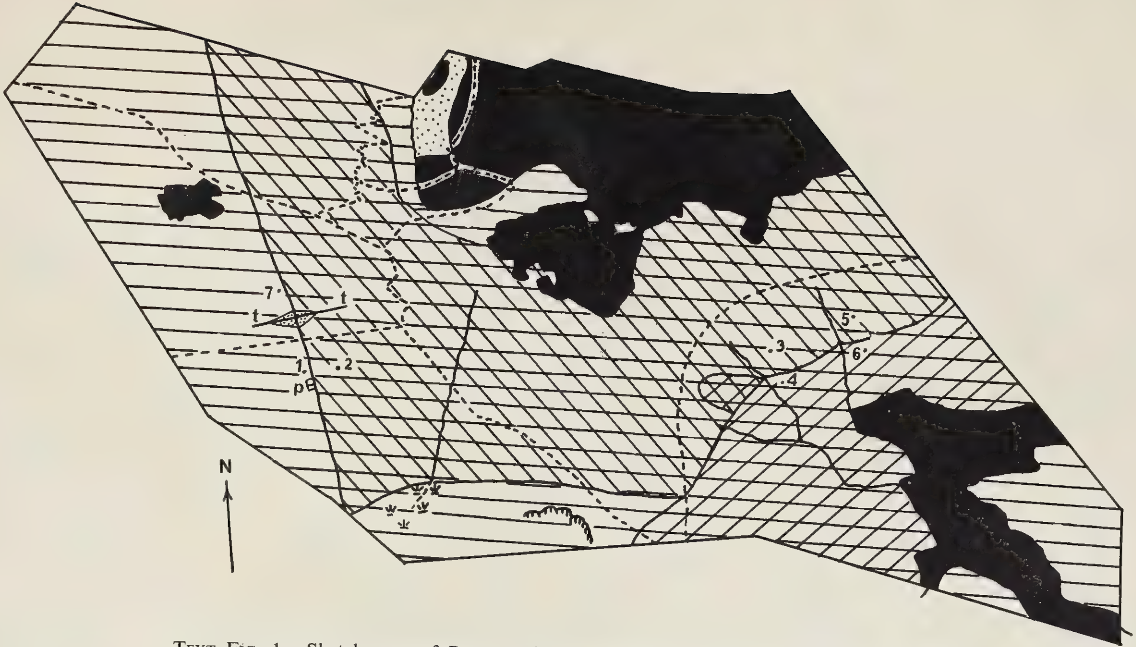
(i) *Cyrtanthus contractus*—by itself—a typical "fire lily" (pl. 1, fig. 1) producing flowering heads without the intervention of a leafy period, almost immediately after burning.

(ii) A group which regenerated vegetatively very quickly and flowered about a month later than *Cyrtanthus*, beginning in October, 1948. This consisted mainly of herbs but a few suffruticose subshrubs (hemixyles) are in this group (e.g. *Clutia heterophylla*).

(iii) A group which began to flower about a month later than group 2, commencing mid November to early December.

(iv) A group, mainly woody but including some herbs, which regenerated very slowly in the first year but flowered in the spring of 1949 or later.

(v) A group which was destroyed by fire and regenerated solely from seed, e.g. *Selago corymbosa*, *Anthospermum aethiopicum*, *Erica chamissonis* and *E. demissa*, and *Cliffortia repens*. The two species of *Erica* did not begin to regenerate until 1950. *Erica* regenerates from seed brought in by the agency of wind, therefore a time-lag may occur especially if a poor seed season occurs after fire. *Anthospermum* has less time-lag than *Erica* and appears so widespread that one assumed it to regenerate from dormant seed present in the soil (Levyns, 1935, showed it to be still 59% viable after 5 years). The fact that seed of *Erica* must fall on the surface, whereas *Anthospermum* may start off from buried seed, probably makes *Erica* more susceptible to drought. The obligate mycorrhizal relationship of *Erica* may also be involved. Attempts to germinate *Erica* seed



TEXT FIG. 1.—Sketch map of Reserve showing approximate areas burnt in 1948 (\\\), 1951 (///), and 1955 (≡); also sites (1—7) of soil thermometers, the positions of the experimental plots (*p*), the unburnt areas left in 1955 (∴∵), and the transect (*t*). Not all to true scale.

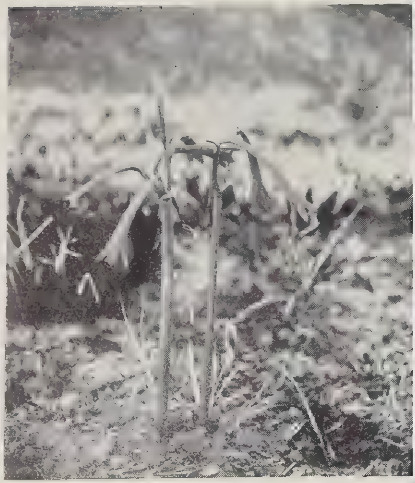


Fig. 1.
Cyrtanthus contractus in flower ca. 20 days after fire. Note flowers damaged by grazing (typical of vlei rat damage to buds).

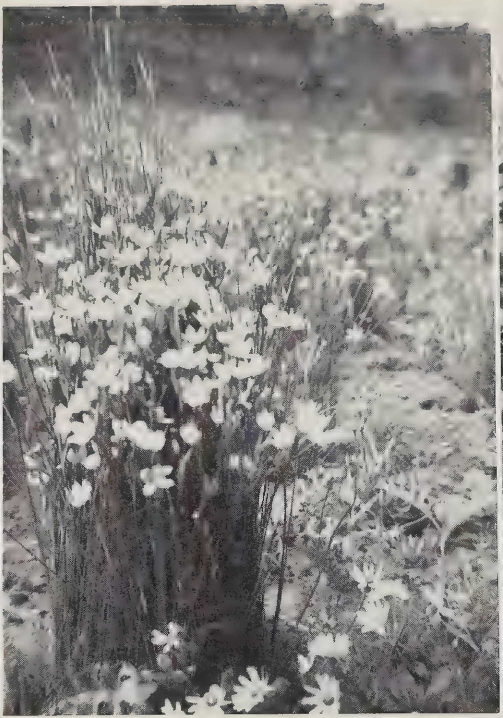


Fig. 2.
Characteristic massed flowering of *Bobartia burchellii* (November, 1948). *B. burchellii* did not flower at all in 1949 or 1950, but flowered profusely on areas burnt in 1951 and 1955. Also present: *Senecio concolor*, leaves of *Berkheya decurrens*.

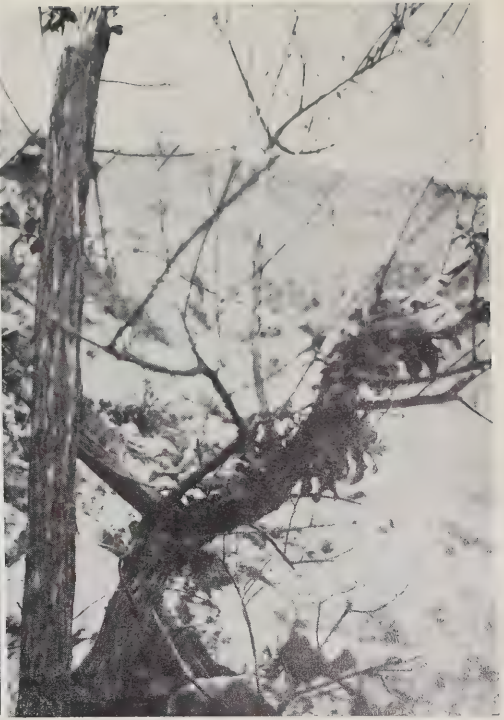


Fig. 3.
Tarchonanthus camphoratus, showing epicormic regeneration typical of many forest and scrub species.

Plate 1.

in Petri dishes led to failure, but in pots of natural soil a high germination rate was achieved.

The system of life forms employed throughout the paper is that of Raunkiaer, modified for shrubs and suffrutices according to the system of Du Rietz (1931).

A close relationship has been demonstrated (Martin l.c.) between the life-form (aeroxyle or geoxyle) and the type of regeneration. Silhouettes of some typical nanophanerophytes of the Reserve are shown in text fig. 2.

TABLE I

Regeneration In Heath After Burning, August 15th, 1948.

	Type in subsequent years.	Raunkiaer Life Forms.
Group I. First seen flowering 1st Sept. 1948.		
Cyrtanthus contractus (Plate 1 fig. 1.)	1	Gb
Group II. First seen flowering 24th Oct. 1948.		
Acalypha peduncularis (Text fig. 6)	2	Gt to H
Anemone caffra	1	Hsr
Clutia heterophylla	1	Ch to G
Eragrostis capensis	1	Hr
Gerbera viridifolia	1	Hr
Hypoxis obliqua	2c	Gt
Senecio concolor (Plate 1 fig. 2)	2c	Hsr
Tulbaghia alliacea	2a	Gb
Group III. First seen flowering 28th Nov. 1948.		
Ajuga ophrydis	2a	Hsr
Anisotoma mollis	2c	Hsr
Berkheya carduoides	2b	Hsr
B. decurrens (Plate 1 fig. 2)	2b	Hsr
Bobartia burchellii (Plate 1 fig. 2)	1	Grh
B. indica	2a	Grh
Diplopappus asper	2b	Hr
Helichrysum appendiculatum	2b	Hsr
Poa binata	2a or b	Hc
Scabiosa spp.	2c	Hsr to Ch
Senecio othonnaeflorus	2a	Hr
Group IV. First seen flowering 30th Oct. 1949.		
Chironia melampyrifolia	4	Ch sb
Helichrysum felinum	3	Hsr
Hermannia flammea	3	Ch
Restio triticeus	3	Grh
Sebaea macrostigma	?	Hsr
Themeda triandra	3	Ch g
(In this group are included shrubs such as Metalasia muricata and Tephrosia grandiflora, where these survive fire. Some did not flower before 1950; Table II)		
Group V. Regenerating only by seed and not flowering before 1949 or later.		
Anthospermum aethiopicum (Text fig. 2)	4	N
Cliffortia repens	4	N
Erica chamissonis (Text fig. 2)	4	N
E. demissa	4	N
Selago corymbosa	4	N

When the drought of 1947–9 ended in the spring of 1949, it was at once noticed that even a year after the fire flowering was much more profuse on burnt than unburnt areas of the Reserve. The flowering of some spring-flowering species was advanced by as much as 14 days (i.e. in flower in August—early September on burnt areas while only in bud on adjacent unburnt areas), but more noticeable was the greater abundance of flowers. Although exact division into classes is always arbitrary, the flora could be divided into groups on this basis also:—

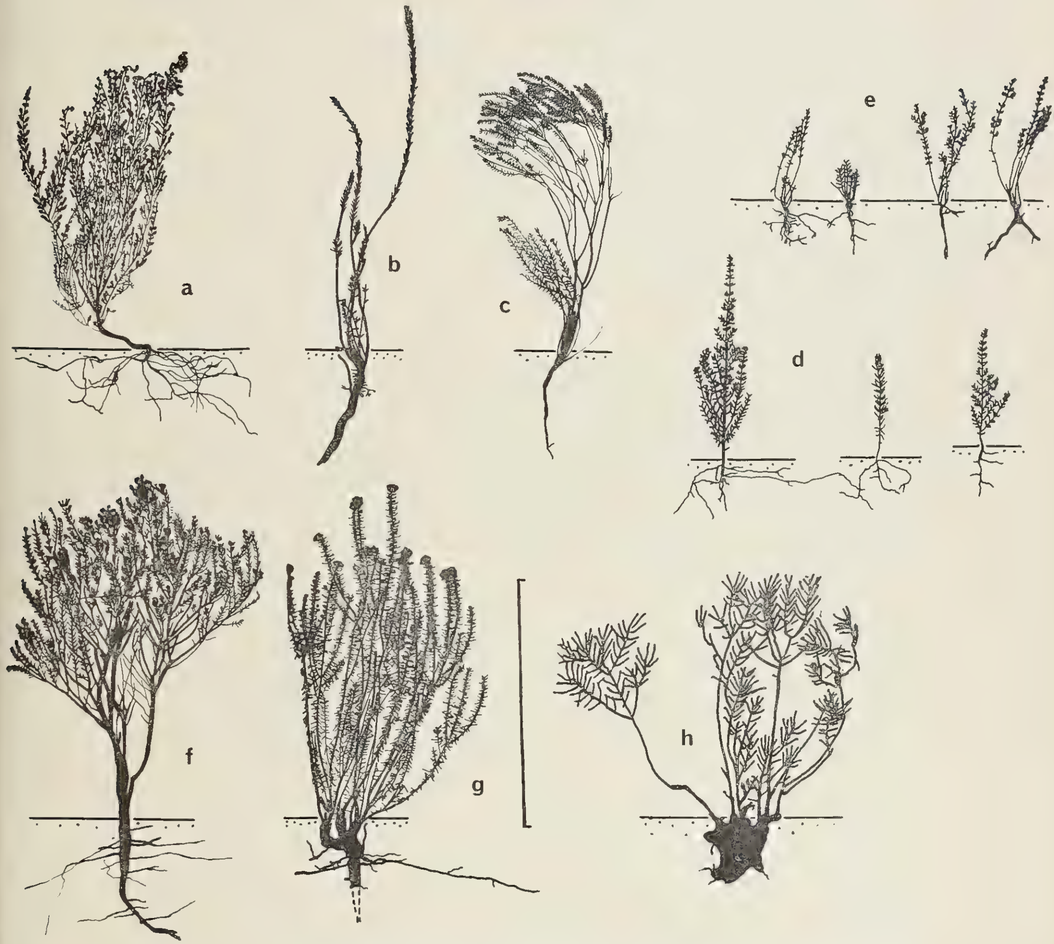
(i) Flowering shortly after fire, very rarely at other times, e.g. *Gerbera* spp.,

TABLE II

Life-forms and regeneration type of some woody plants in the Grahamstown Nature Reserve 1948—52.

Species	Root System where known	Life form (du Rietz Classification)	Seed establishment
A. Regenerating Vegetatively From Base			
Agathosma peglerae	Thick deep corky & woody tap root	1. *Holoxylic*	Not seen.
Berzelia intermedia	?		Not seen.
Leucadendron salignum	Thick fleshy & corky ligno-tuber. (Text fig. 2)	Geoxylic erect	Not seen.
Metalasia muricata	Thick woody tap root (Text fig. 2)	sedentary dwarf*	Seedlings infrequent.
Montinia caryophyllacea	?	shrubs	Seed highly viable, but seedlings not seen.
Phylica axillaris †	Deep woody tap root (Text fig. 2)		Seedlings infrequent.
Psoralea pinnata	Deep woody tap root, shallow laterals	*	Seed large, with dormancy. Seedlings produced in small nos.
Struthiola argentea	Complex woody fibrous adventitious system		Not seen.
Cliffortia linearifolia	Thick woody stock & fibrous laterals	Similar, semi-sedentary (weakly suboliferous)	Seedlings frequent in good conditions.
		2. *Hemixylic*	
Anthospermum paniculatum	Small woody stock-like tap root with relatively well developed shallow laterals (Text fig. 2)	Geoxylic erect	Not seen.
Erica cerinthoides	Thick deep woody tap root (Text fig. 2)	sedentary half	Not seen.
E. glumaeflora		shrubs	Seedlings rarely seen.
Clutia heterophylla	? Tuberous	Geoxylic semi prostrate	Not seen.
Indigofera hilaris	? Tuberous	sedentary half shrubs	Not seen.
B. Not Regenerating Vegetatively		1. *Holoxylic*	
Anthospermum aethiopicum	Thin long tap root, small laterals (Text fig. 2)	Aeroxylic erect	Seed with dormancy, establishing well.
Cliffortia repens	Shallow laterals predominate over tap root	sedentary	Establishes well by seed.
Erica chamissonis	Shallow spreading laterals, no tap root (Text fig. 2)	dwarf	Seeds minute, establish very well under good conditions.
E. demissa		shrubs	
Metalasia gnaphalodes	Long woody tap root, & laterals (Text fig. 2)	Similar but (?) sometimes	Seedlings rarely seen.
Ursinia anethoides	Thin long tap root, small shallow laterals	geoxylic	Seedlings infrequent.
Psoralea spicata	?	Similar, true long-shoot shrub	Seed dormancy, establish well after fire.
		2. *Hemixylic*	
Selago corymbosa	Shallow thin tap root & laterals	Aeroxylic erect sedentary half shrub	Establishes well from seed.

* May reach size of small tree elsewhere.
† Regenerated poorly in 1948, during drought.



TEXT FIG. 2.—Silhouettes of some shrubs showing root systems and aeroxylic (A) *v.* geoxylic (G) life-form: (*a*) *Erica chamissonis* (A), (*b*) *Erica cerinthoides* (G), (*c*) *Phylica axillaris* (weakly G), (*d*) *Anthospermum aethiopicum*, 6mo., 12 mo., and 18 mo. seedlings (A), (*e*) *Anthospermum paniculatum* (G), (*f*) *Metalasia gnaphalodes* (A), (*g*) *Metalasia muricata* (G), (*h*) *Leucadendron salignum* (lignotuber G).

Clutia heterophylla, Cyrtanthus contractus, Bobartia burchellii, (Pl. 1, fig. 2) *Graderia scabra.*

(ii) Similar behaviour to group 1 after fire, flowering less frequently subsequently.

- (*a*) Those showing a strongly stimulated effect only in the year of burning.
- (*b*) Those in which the effect diminishes slowly over two or three years.
- (*c*) Flowering readily in unburnt areas but showing a stimulated effect after burning, e.g. *Senecio concolor,* (Pl. 1, fig. 2), *Scabiosa* spp.

(iii) Flowering not occurring in the first year but more prolific in second and third years, e.g. *Themeda triandra, Restio triticeus.*

(iv) Flowering not occurring after burning and not noticeably stimulated in subsequent years—seen in many shrubby spp. where these survive fire, e.g. *Phylica axillaris.*

(v) Flowering apparently unaffected by burning, e.g. certain autumn and winter flowering species, e.g. *Dierama pendulum, Leonotis leonurus.*

Geophytes and hemicryptophytes are generally stimulated and fall in groups 1 & 2. They either behave as long-day plants, or are day-length indifferent. Chamaephytes and herbaceous phanerophytes capable of regeneration from the base or from below ground may be of several types but group 3 is perhaps the most typical. Shrubby plants are mostly of group 4. Group 5 are short day plants of various life forms.

(2) QUADRAT DATA.

The quadrat data (Table III) were from the burnt and unburnt areas in the spring and summer of 1949–50, a year after the burning. By this time, as shown above, a number of species had reappeared which had not regenerated immediately after the fire, perhaps, in many cases, through dormancy because of the drought, or owing to a natural slowness of growth.

The quadrats, 1 m. square, were thrown at random in the burnt and unburnt heath, the only selection exercised being to distribute them roughly in two lines about ½ mile long on opposite sides of the edge of the burn. Thus each quadrat in unburnt heath had an approximate pair in the burnt heath. The number of individuals of each species in each quadrat was counted. The comparison, however, between the two sets must be viewed in the light of the very definite non-random dispersion of species, as illustrated for instance by *Metalasia gnaphalodes* which with a frequency of 8 and density of 166 in the unburnt heath was clearly very much over-dispersed. Its apparent absence from burnt heath, could not therefore, without supporting evidence, be taken to imply poor regenerating power, but might be a result of insufficient sampling.

The absence of the grass *Elyonurus argenteus*, a species apparently without marked over-dispersion, seems to imply its destruction by fire or else very delayed vegetative regeneration. Other grasses, however, have spread. Of these,

TABLE III

Frequency and Density of Species in Quadrats, Burnt and Unburnt Areas 1949–1950

Species	Burnt Area		Unburnt Area	
	Fr.	No/ 25 sq.m.	Fr.	No/ 25 sq.m.
Pteridophyta				
Pteridium aquilinum	24	79	—	—
Coniferae				
Pinus spp. *saplings*	4	1	—	—
Gramineae				
Aristida galpini	24	51	28	10
Alloteropsis semialata	36	42	64	58
Cymbopogon marginatus	12	11	20	13
Brachiaria serrata	12	30	20	10
Elyonurus argenteus	—	—	36	29
Eragrostis capensis	28	15	16	8
E. curvula	28	14	12	6
Eulalia villosa	20	15	24	14
Harpechloa falx	12	20	24	20
Pentaschistis augustifolia	12	6	16	17
Panicum perlaxum	36	53	8	8
Setaria flabellata	4	240	12	23
Sporobolus capensis	28	10	12	3
Themeda triandra	56	120	80	88
Tristachya hispida	11	7	24	17
Cyperaceae				
Bulbostylis sp.	8	22	—	—
Ficinia spp.	42	48	8	16
Schoenoxiphium sparteum	72	87	40	48
Other Monocots				
Aristea pusilla	32	10	16	11
Bobartia burchellii	8	2	24	41
B. indica	12	15	28	11
Hypoxis obliqua	28	16	40	23
Restio triticeus	24	70	56	65
Compositae				
Athanasia punctata	—	—	24	17
Berkheya carduoides	36	88	32	12
B. decurrens	48	41	36	24
Disparago ericoides	8	2	16	20
Gazania longiscapa	32	14	4	1
Gerbera piloselloides	20	7	4	1
G. viridifolia	56	68	16	12
Helichrysum anomalum	4	2	24	16
H. appendiculatum	36	17	12	3
H. felinum	12	12	40	48
H. nudifolium	76	122	88	82
H. subglomeratum	36	73	72	110
Metalasia gnaphalodes	—	—	8	166

Species	Burnt Area		Unburnt Area	
	Fr.	No/ 25 sq.m.	Fr.	No/ 25 sq.m.
M. muricata	24	25	16	14
Senecio concolor	76	134	24	6
S. othonnaeflorus	64	78	52	73
S. pterophorus	24	28	—	—
Ursinia anethoides	—	—	16	47
Leguminosae				
Amphithalea williamsonii	—	—	8	5
Indigofera spp.	12	27	—	—
Psoralea pinnata	16	7	4	3
Tephrosia capensis	28	123	24	16
Other Dicotyledons				
Acalypha peduncularis	8	25	28	51
Alepidea ciliaris	28	12	72	46
Anisotoma mollis	20	12	8	2
Anthospermum aethiopicum	56	120	56	72
A. herbaceum	20	12	4	1
A. paniculatum	16	5	32	28
Centella eriantha	68	114	32	51
Chaetacanthus setiger	36	24	20	9
Chironia spp.	4	1	16	11
Cliffortia linearifolia	36	38	20	22
C. repens	8	18	8	11
Clutia alaternoides	—	—	8	5
C. heterophylla	20	11	36	20
Erica chamissonis	—	—	20	23
E. demissa	—	—	36	103
Euphorbia striata	24	7	—	—
Gnidia sericea	20	7	4	1
Hibiscus aethiopicus	28	25	32	8
Oxalis spp.	34	25	20	9
Phylica axillaris	—	—	28	16
Polygala hispida	28	21	20	11
Scabiosa spp.	20	9	12	11
Selago corymbosa	24	31	4	3
Struthiola parviflora	28	21	4	3
Thesium spp.	22	12	8	2

Density Differences

	Burnt	Unburnt	Increase or Decrease	Change %
Total Pteridophyta	86	2	+ 84	—
Total Gramineae	712	369	+343	+ 93
Total Cyperaceae	161	69	+ 92	+132
Total other Monocotyledons	132	171	− 39	− 23
Total Leguminosae	189	60	+129	+245
Total Compositae	783	698	+ 89	+ 13
Total other Dicotyledons	553	622	− 69	− 11
Total all species	2616	1987	+629	+ 32

Setaria flabellata is interesting in having occupied certain small areas very effectively. *Themeda triandra* had dropped in frequency, but increased in density locally, this being quite a general trend. The fire had evidently destroyed some individuals completely, but those not destroyed regenerated vigorously. Thus over-dispersion is more typical of the burnt area. Taking the grasses as a whole, number of individuals counted as separate tufts approximately doubled, while few species have increased at all markedly in frequency. Cyperaceae, especially *Ficinea*, have behaved like the Gramineae. Monocotyledons other than these show very little numerical response. *Pteridium* is strongly over-dispersed and its absence from the unburnt quadrats is due partly to sampling deficiency. In unburnt heath, the fronds are scattered and it is rarely dominant. The results from the burnt area appear to illustrate its vigorous response to burning, numerous young fronds being formed. (The observations of 1956 to be discussed later, show the apparently contradictory results for *Pteridium* that may result from fortuitous distribution effects.)

Among Dicotyledons, Leguminosae and Compositae show numerical increases, that in legumes being chiefly due to *Indigofera stricta* and *I. hilaris* (early stages in regeneration of which could not be reliably separated) and *Tephrosia capensis*, while the Compositae show an increase in *Berkheya* spp., *Gazania*, *Gerbera*, *Helichrysum nudifolium* and *Senecio concolor*. *Senecio pterophorus* is of interest as being one of the few outside species which have successfully colonised the burnt area. This species is absent from unburnt heath, the seed source presumably being the *Senecio pterophorus* dominated areas in exotic pine forest along the top of the ridge. Dicotyledons, other than these two families, show a slight overall decrease, mainly due to the destruction of *Phylica axillaris*, *Erica* spp., the legume *Amphithalea williamsonii* and the Composite *Ursinia anethoides*, though there has been some compensating increase in *Anthospermum aethiopicum*, *Selago corymbosa* and *Centella eriantha*.

Thus in general, species typical of grassland have been favoured at the expense of species of heath. This might have been even more marked had the drought been less intense, though the observations of section 3 show that *Amphithalea*, *Phylica* and *Ursinia*, might have persisted and *Erica demissa* returned sooner, under moist conditions.

(*b*) Further burning on the Nature Reserve, 1951.

Grass and heath fire broke out on the Howisons Poort hills on 3rd August, 1951, and spread into the Reserve at the southern end near Howisons Poort road. It burnt across the Reserve, being halted by fire breaks and confined on the whole between the lower forest patch and the old burn.

This was the first opportunity to visit the site of a fire immediately after it occurred. On the 5th August it was only observed that burning was almost complete and very little above-ground vegetation had survived. Bushes of *Rhus fastigiata* and other indigenous shrubs however were often only defoliated and scorched around their base, and very few appeared completely destroyed. A few bushes of the exotic *Hakea* which had escaped eradication were more thoroughly burnt and their opened refactory fruits were shedding seed.

Six days later, no rain having fallen in the meantime, grass had grown ca. ½—1 in. from the base of some tussocks, showing that generally death did not occur below the soil surface, though in a few places the tussocks appeared to have been completely killed. Probably the temperature of the fire varied locally.

By August 13th faunistic activity was noted in the burnt area. Round the bases of many of the burnt bushes, colonies of ants which had apparently survived the fire were active. A minute spider, spinning threads from tip to tip of the burnt stalks of grasses was noticed, the whole area being copiously covered by these fine threads; apart from the ants, this appeared to be the commonest animal in the area. Its webs were also seen on the recently cut paths, but were not observed frequently in the undisturbed areas. The ecology of this (unfortunately unidentified) spider seems worth further investigation. Fresh dung of vlei rats (*Otomys* sp.), very common in regenerating and mature vegetation, was absent here, presumably because these mainly herbivorous animals had nothing as yet to invite them into the burnt area.

Observations following this fire made possible an extension and a revision of the previous work. Firstly, it was noted that although the fire, aided by a strong westerly wind, burned up to the very edge of the area burnt in 1948, it hardly anywhere crossed this boundary, which still formed a natural fire break since the regeneration of the area during and since the drought had evidently not produced sufficient herbage or fuel to burn again. Where such burning did occur it was patchy and incomplete. The burning of experimental plots in 1950, to be described presently, had demonstrated that the fire proceeds through vegetation like a chain reaction; each unit of vegetation must be raised to the combustion point, when it ignites almost explosively. If these chains of heating and ignition break more often than they proceed, the fire becomes patchy or dies out. A succession of good growth years followed by drought will produce a more inflammable product than a succession of drought years, and it is probably impossible to burn the same heath at intervals of less than four years under average local conditions. A third variable in the "equation of combustibility" is the nature of the herbage being produced. Grassland for instance, because it produces a more uniform cover, might burn more frequently. The fires of 1948, 1951 and 1955 have demonstrated that the scrub and woodland are very difficult to burn under any conditions.

The second feature demonstrated by the 1951 fire was the ability of some species to regenerate, either vegetatively or by seed, under conditions of good rainfall, though they failed in drought. Thus *Phylica axillaris*, *Amphithalea williamsonii* and *Ursinia anethoides*, which had appeared to be exterminated in the area of the 1948 fire, regenerated reasonably well in the area of the 1951 fire, while *Themeda triandra* and *Restio triticeus* which delayed regrowth in the former until 1949, regenerated more promptly in the 1951 area. The most impressive difference was seen in the behaviour of *Erica demissa* and *E. chamissonis*. These plants had flowered in the spring of 1948 despite the drought, but no germination took place except in a few particularly sheltered areas—along gully banks, in crevices and damp moss beds. In 1949 the intensity of drought was such that buds did not open and withered on the plants. Scarcely any flowering occurred. In 1950 flowering was normal, rainfall was good during the spring and seedlings began to appear in the area of the 1948 burn though not in the plots burned in 1950. *Erica* seedlings first appeared in these plots after the 1951 flowering season, showing that a one year delay is normal but two years is not. Regeneration of *Erica* on the 1951 burn was observed in 1952. The light seed was apparently wind-borne into the burnt area for distances as great as 300 to 400 yards in extreme cases.

The main area of unburnt *Erica demissa—E. chamissonis* heath had been confined by the two fires to an area about 300 yards wide and from top to bottom of the Reserve along its western margin (Text fig. 1). Reseeding of areas remote from this was due mainly to isolated plants which had survived on rocky outcrops, "nunatak"-like, untouched by the fires, and in some areas of its former dominance, due to the absence of seed sources, regeneration of *Erica* remained negligible even in 1952.

Experimental And Analytical Studies

(*a*) Burning of experimental plots.

Since the original vegetation of the burnt part of the Reserve could only be guessed at, a small experimental burning was made in August, 1950, about the same time of year as the original burning. The objects were (*a*) to study the effect on nitrification and other bacterial processes, (*b*) to find what temperatures were reached at the soil surface and at a depth of a few cms., (*c*) to study the effect of removal of brushwood on the temperature of the burn, and (*d*) to study the regeneration of a part of the Reserve, the former vegetation of which was accurately known, so that from it, some better idea of the former vegetation of the Reserve could be obtained.

(1) SELECTION AND TREATMENT OF PLOTS.

Owing to the danger of burning the whole of the remaining vegetation, only a small plot was chosen. It was divided into two 5 m. sq. sub-plots separated by a firepath 1 m. wide. From one of these as much as possible of the brushwood

TABLE IV

List of species occurring in experimentally burned plots

(Symbols in parenthesis are those used in figs. 5 and 8)

*= actually in plot

Dicotyledons	
Alchemilla capensis (*Alc*)	o*
Anthospermum aethiopicum (*A*)	f*
A. herbaceum (*Ah*)	r*
A. paniculatum	o
Argyrolobium stipulaceum	o
Berkheya carduoides (*Bc*)	o–f*
B. decurrens (*Bd*)	f*
Burchellia bubalina	o
Centella eriantha (*Cn*)	r*
Chaetacanthus setiger (*Ch*)	f–a*
Cliffortia linearifolia (*C*)	d*
C. repens	l. f–d
Clutia heterophylla	f*
Crassula ericoides	r*
Disparago ericoides	f*
Dobrowskya scabra (Dw)	r*
Drosera cuneifolia	o–f*
Erica chamissonis (Ec)	f*
E. demissa (d)	d*
Gerbera piloselloides (Gp)	o*
G. viridifolia (G)	f*
Gymnosporia angularis	o–f
Haplocarpha lyrata	o–f*
H. scaposa	o–f
Helichrysum anomalum	r
H. appendiculatum (Ha)	o*
H. felinum (Hf)	o*
H. nudifolium (Hn)	o*
Helichrysum petiolatum	l*
H. subglomeratum (*Hs*)	f*
Hermannia flammea	o*
Hibiscus aethiopicus (*Hi*)	f–a*
Hypericum lalandii (*Hy*)	o*
Indigofera poliotes	o*
I. sp.	o–f*
Lobelia tomentosa (*L*)	o*
Metalasia muricata (*M*)	f*
Ochna atropurpurea	o*
Oldenlandia amatymbica (Ol)	o*
Oxalis smithiana	o–f*
O. spp. (x)	f–a*
Pimpinella schlechteri	f–a
Pinus pinaster	r*
Psoralea spicata	l
Rhus eckloniana	o
R. fastigiata/pyroides	o
Rhynchosia totta (Rh)	f*
Royena pubescens	o
Scabiosa anthemifolia (Sb)	o*
Senecio concolor (S)	f*
S. othonnaeflorus (So)	o*
Struthiola macowani	o–f
S. parviflora (St)	o
Tephrosia grandiflora (Tep)	o
Thesium junceum (Thj)	o–f*
Thunbergia alata	o*
Monocotyledons	
Alloteropsis semialata	f*
Aristea spp. (Ar)	o*
Bobartia indica (B)	l–a*
Brunsvigia grandiflora	o
Eragrostis cf. curvula (Eg)	l*
Ficinia sp. (F)	a*
Hypoxis obliqua (Hv)	f*
Panicum perlaxum	o*
Pentaschistis angustifolia (Ps)	f*
Restio triticeus (R, Rt)	a*
Satyrium membranaceum	r*
Schoenoxiphium sparteum (Sch)	f*
Setaria flabellata (Set)	f*
Themeda triandra (T)	f–a*
Pteridophyta	
Pteridium aquilinum (Pt)	l. f–l.a

was removed. A permanent metre quadrat was placed in each sub-plot and the vegetation accurately mapped (Text fig. 5*a*).

The vegetation was dominated by *Erica demissa* and *Cliffortia linearifolia* which formed a dense community varying in height from 12 ins. to 36 or 48 ins., and averaging 24 in. Table IV is a list of the plants in or near the two plots. The list of Monocotyledons is incomplete, since at the time of listing very few were flowering and from the leaves it is very difficult to identify them.

In collecting the debris from the plot which was cleared, it was noticed that many of the still rooted stumps bore burn marks, and such marks were seen also on stumps throughout the area; the community was not completely undisturbed but had previously been burnt. Signs of former disturbance were also seen in the occurrence of chopped-out pine stumps and narrow overgrown paths.

The dead brushwood and debris from the plot amounted to 10 kilograms. From the 1 m. quadrat in this plot as much as possible of the finer litter was also removed. The combined brushwood and litter from this quadrat was 1 Kg. 20 gm. (Plate 2, Fig. 4). Most of the brushwood was recognised as *Erica demissa, E. chamissonis*, *Cliffortia linearifolia*, etc. The fine debris consisted of small sections of stems of *Erica* and *Cliffortia*, small sections of leaf and stem of *Restio* and *Bobartia*, leaves of *Erica* and *Cliffortia*, *Erica demissa* fruit capsules and grass leaves. Some 20 gm. of animal pellets were separated, ca. 2% of the total organic matter.

On a second metre plot outside the burnt area, clearing was attempted in the same way, the plot being chosen at random. A total of ca. 870 gm. of plant material was extracted; the components were the same as before, but animal pellets amounted to only about 12 gm. In both cases beetle elytrae or other insect remains amounted to ca. 0·1 gm., a not very significant part of the whole.

The average of these two quadrats, ca. 945 gm., suggests that a value of nearer a kilo/sq. m. is a better estimate than that obtained for the plot as a whole by less thorough collecting. In each quadrat the amount of debris extracted by careful sweeping after rough hand picking of coarser debris amounted to about $\frac{2}{5}$ of the total ca. 380 grms./m^2. A minimum factor of about $\frac{2}{5}$ by weight should be added to the value obtained by coarse picking and the figure for the plot might be as high as 23 Kg.

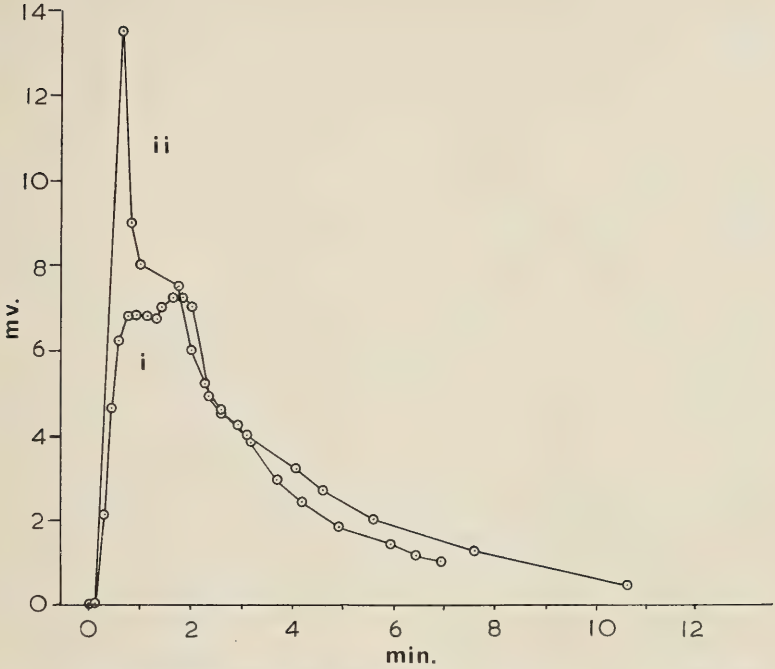
(2) RESULTS OF BURNING.

(i) *Method.* Brushwood, soaked in kerosene was ignited against the windward end of each plot. Fire spread into the plots and burned across them, fanned by a strong breeze. The surface temperatures were recorded with a thermocouple and small capillary tubes filled with various organic compounds (Beadle 1940) were laid on the surface. In each case, care was taken to see that the thermocouple junction was in actual contact with the soil surface, though not covered. Sub-surface soil temperatures were recorded with melting point tubes only.

(ii) The uncleared plot burned easily and rapidly, except for a small patch in one corner. The fire burned forward both in the crowns of the plants and at the ground level, the crown fire preceding the surface fire by about a foot. The advancing margin may be likened to the advancing wave of a steady state chain reaction in which foci of combustion are formed at the same rate as they die out. The compounds in the melting point tubes at the surface were volatilised and the thermocouple measured a maximum e.m.f. of 13·5 mv. (corresponding to 550°C. Text Fig. 3). Crown temperatures were probably higher. Sub-surface soil temperatures however did not rise greatly, and menthol (melting point 43°C) at a depth of $\frac{1}{2}''$ did not melt.

The first attempt to ignite the cleared plot failed and extra brushwood was added. The fire then burned about half-way across before going out, and a third attempt was made. This time the fire burned across in the middle, leaving two unburnt patches on either side which were burned off separately with the aid of more brushwood. Even then the burning was not very complete, and the attempt to obtain uniform burning was abandoned. The thermocouple measured a maximum e.m.f. of 7·2 mv. (350°C) and the organic compounds in the surface series of tubes were melted but not completely volatilised; at $\frac{1}{2}''$ depth the temperature did not exceed 43°C. There seems little doubt that this difference in behaviour of the two plots was due to the removal of brushwood from the upper one. Actual temperatures recorded by the thermocouple will of course depend on the amount of combustible material in its immediate neighbourhood; such local differences might conceivably have been recorded on the same plot had more than one thermocouple been available, but the failure of the organic compounds in the tubes to volatilise on the cleared plot also indicates lower temperatures generally. The vegetation on the cleared plot was less tall, but this was made up mostly in stem height and combustibility depends much more on density of the crowns. Since the stems were not consumed, it seems unlikely that height alone was responsible for the difference.

The thermocouple readings show that temperatures did not remain high for more than 120 seconds at either spot. Half an inch of soil could thus form an effective insulator. The temperatures recorded above would not destroy living subterranean parts of plants, nor are they likely to have a marked direct effect on the soil and its microfauna and flora. Indeed, ants, thread-spinning spiders, etc. were noted abundantly active only two days after the fire, as they were later after the 1951 fire. The effect on protozoa and bacteria might be

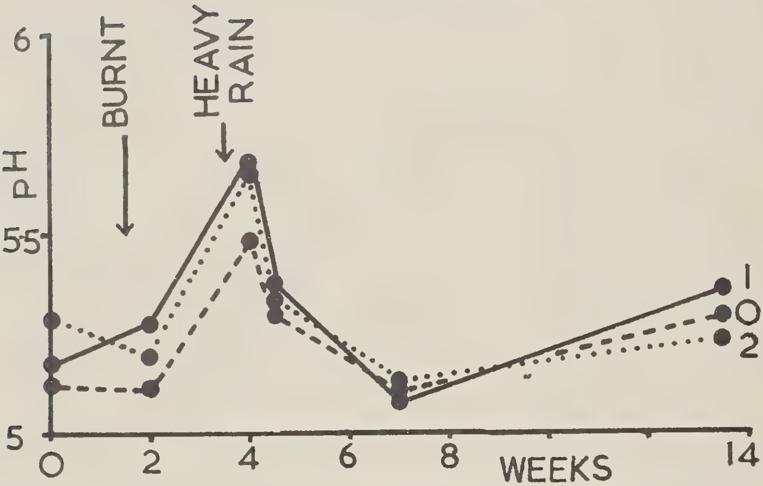


TEXT FIG. 3.—Surface temperatures (recorded in mv.) during burning of experimental plots: (i) cleared of brushwood and litter, (ii) not cleared.

to produce temporary encystment or spore formation. While no doubt mortality is widespread in the top ½″ of soil, it will not be severe below this. The effect requires more careful investigation. There may be a possible association between destruction of superficial soil biota and the failure of strongly mycorrhizal species such as *Erica demissa* to germinate in the first season following burning.

Regeneration in the burned plots was studied by detailed plotting of the quadrats at intervals, the last examination being made in November, 1952.

The soil moisture and pH were analysed in the period immediately after the fire by taking samples from the corners of the quadrats. Fresh samples were taken at intervals from alongside the earlier ones for a 14 week period. However, no permanent change was observed in pH (Text Fig. 4). The sharp rises on some days are attributed to heavy rain which waterlogged the soil just prior to sampling. PH readings regularly changed in this way after rain, and were similar on the unburned control plot.



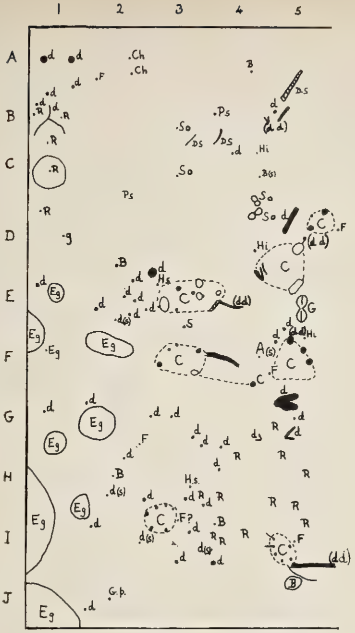
Text Fig. 4.—Course of pH changes in samples from corners of quadrats in plots. With the exception of the sharp temporary rise in all curves following heavy rain (probably a dilution effect), the changes over a 14 week period appear to be random. 0 = unburnt control, 1 = plot cleared of brushwood and litter, 2 = uncleared plot.

The maps of the quadrats need not be shown in full. A section of the quadrat on the cleared plot is shown giving the four sets of results (Text Fig. 5). This area is typical of both quadrats. However, some differences in regeneration were observed between the plots. Table V gives the numerical data for both the quadrats.

The most striking differences are firstly the difference in establishment of *Erica demissa* seedlings in 1951, when only 10 seedlings appeared in the uncleared quadrat compared with 55 in the cleared, and secondly the long-standing difference in establishment of grasses, which began to appear immediately after burning, some 200 apparent seedlings being established in the uncleared quadrat in 1950 and 1951, compared with fewer than 30 in the cleared quadrat. *Themeda* was confined to the uncleared quadrat, *Eragrostis* to the cleared one. As these differences may reflect initial differences between the plots rather than differences brought about by the clearing, they cannot be usefully discussed in great detail.

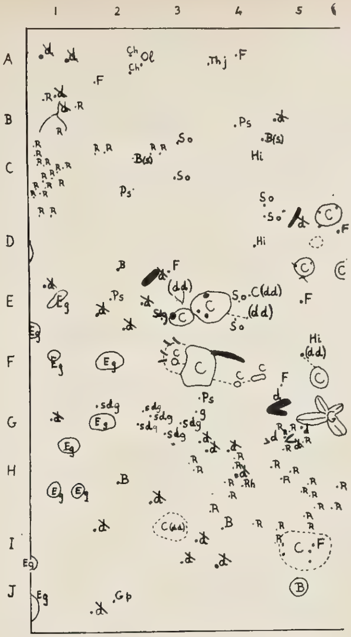
Text Fig. 5.—Part of mapped quadrat. Example is from plot cleared of brushwood: (i) before burning, (ii) 2 mo. after burning, (iii) 14 mo. after burning, (iv) 26 mo. after burning. Symbols are as in Table IV with the addition of the following: (*dd*) = dead, d = *Erica demissa* stump, *g* = unidentified grass (apparent seedling), *Pa* = *Parmelia*, (*s*) = seedling, *sdg* = unidentified seedling.

i



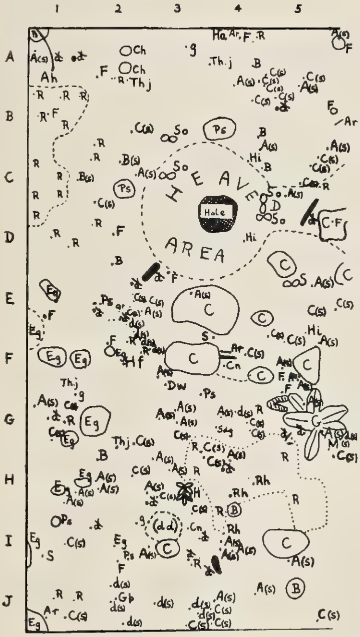
1
2
3
4
5
A
B
C
D
E
F
G
H
I
J
Eg
C
(dd)
So
Ps
Hi
Hs
R
d
B
F
Ch
DS
G.p.

ii



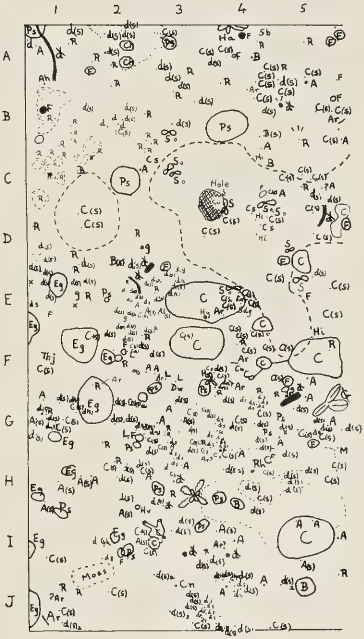
1
2
3
4
5
6
A
B
C
D
E
F
G
H
I
J
Eg
C
(dd)
So
Ps
Hi
Thj
Ol
Ch
sdg
Rh
B(s)
Gp

iii



1
2
3
4
5
A
B
C
D
E
F
G
H
I
J
HEAVY AREA
Hole
Ah
Ch
Th.j
Ha
Ar
Ps
So
Hi
Eg
C
C·F
Hf
Cn
Dw
Sdg
Rh
(dd)
Gb
A(s)
C(s)
d(s)

iv



1
2
3
4
5
A
B
C
D
E
F
G
H
I
J
Hole
Moss
Ps
Ah
Ha
Sb
Thj
Eg
C
C(s)
A(s)
d(s)
Hi
So
Dw
Rh
Cn

The similarities between the plots are of greater immediate interest. These similarities are (i) establishment of plants by seed is most marked for certain species:— *Erica* spp., *Anthospermum aethiopicum, Cliffortia linearifolia* and Gramineae. Only *Cliffortia linearifolia* regenerated well both from stocks and from seed. (ii) Once established, the shrub seedlings seem to have a high initial survival rate, *Erica demissa* averaging ca. 82% for the two quadrats, *Anthospermum* ca. 86%, *Cliffortia* 70% for the cleared quadrat and 56% for the uncleared. Gramineae however showed a survival rate (1951 to 1952) of 65% in the cleared quadrat (based on only 17 individuals) compared with 32% in the uncleared quadrat (based on 223 individuals). These counts are very crude, being based principally on coincidence of position and on increase in size between November, 1951 and November, 1952. Clearly these are maximum values, as no account is taken of seedlings established later than November 1951 and dying before the next census, or of false coincidences. On the other hand, it is unlikely that many seedlings would become established during the hottest summer months and *Erica demissa* in particular has a sharply demarcated flowering season and no seed dormancy, which would make establishment except in early summer very improbable. For this species, at least, it may be assumed that the survival values are fairly accurate. Except for *Erica* fewer obviously new seedlings appeared in 1952 than in 1951, which also suggests that most seedlings appear in the first year. (iii) Few seedlings of other plants appeared and values for survival have not been calculated. It is remarkable that so many of the hemicryptophytes (principally Compositae) and chamaephytes

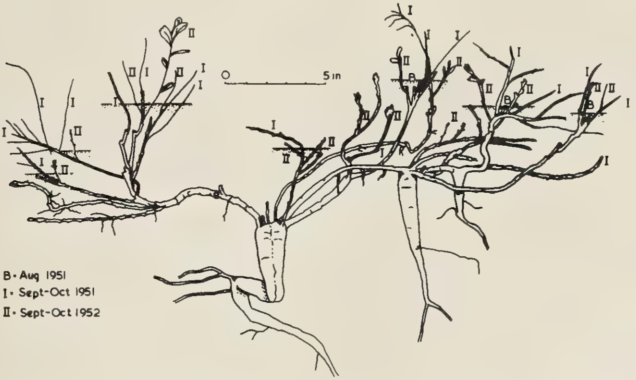
TABLE V

Composition of Cleared and Uncleared Metre Quadrats on Plots Experimentally burned August, 1950

	1950 before burn		1950 after burn		1951		1952	
Species	Un-cleared	Cleared	Un-cleared	Cleared	Un-cleared	Cleared	Un-cleared	Cleared
Erica demissa (adult)	31	84	—	—	—	—	—	—
E. demissa (seedlings)	1	13	—	—	10	55	114	303
E. chamissonis (adult)	1	—	—	—	—	—	—	—
E. chamissonis (seedlings)	—	—	—	—	—	—	6	1
Anthospermum aethiopicum (adult)	—	—	—	—	—	—	28	55
A. aethiopicum (seedlings)	10	2	—	1	30	62	4	10
Cliffortia linearifolia (adult)	17	16	13	17	14	17	13	18
C. linearifolia (seedlings)	—	—	—	—	45	137	103	98
Themeda triandra (adult)	4	—	2	—	3	—	14	—
Themeda (apparent seedlings)	—	—	—	—	11	—	—	—
Other *Gramineae* (adult)	18	18	7	10	10	20	74	28
Other *Gramineae* (apparent seedlings	17	—	205	18	213	17	68	6
Cyperaceae	13	6	12	8	22	22	15	32
Bobartia spp. (adult)	7	8	7	7	7	10	14	12
Bobartia (apparent seedlings)	—	—	—	—	7	3	4	5
Oxalis spp.	19	—	2	—	35	—	59	4
Compositae	5	7	8	14	23	20	28	22
Restio	7	14	2	55	1	40	4	127
Leguminosae	—	1	—	1	—	4	—	2
Miscellaneous (adult)	19	15	20	23	46	32	27	37
Miscellaneous (apparent seedlings)	—	2	—	14	—	6	19	18
Total individuals	170	186	278	168	457	445	594	778

represent fire survivals. In the majority of instances where a seemingly new plant appeared, this would be found on closer examination to have sprung from a pre-existing, often apparently dormant, root-stock. A difficulty in assessing the number of true seedlings is the impossibility of deciding without dissection from the soil, whether a given plant represents an individual or a sucker produced from another adjacent plant. Besides many Compositae, *Graderia scabra*, *Hibiscus aethiopicus* and *Clutia heterophylla* are probably mainly formed from such subterranean stocks or tubers. Text fig. 6, representing an individual of *Acalypha peduncularis* dissected from the soil, illustrates the great difficulty one would have, without total dissection, of identifying individuals of species with this type of life form. In practice, only the observation of cotyledons could be accepted as clear evidence of the seedling nature of individuals.

The data from the two quadrats, in conjunction with the data from the 1956 transect in the same area, give a fairly clear picture of regeneration after burning. *Cliffortia linearifolia* is hardly affected apart from the death of a few moribund stocks, and is increased by the establishment of suckers and of seedlings from dormant seed. However, many of these must die eventually as no great increase in numbers occurs. *Anthospermum aethiopicum* adults are killed but regeneration is rapid from dormant seed and the young plants are already beginning to flower in the second year when 8 ins. high. This species probably reached its



TEXT FIG. 6.—Plant of *Acalypha peduncularis* dissected whole from soil. B = stem endings charred by 1951 fire; I = shoots referable to spring (Sept) 1951; II = shoots referable to spring 1952. In both growth periods shoots have proceeded in majority of cases from buds below the surface (geophytic behaviour). The difficulty of deciding the limits of an "individual" without dissection from the soil is well illustrated.

maximum importance between the third and the sixth year and is beginning to die off thereafter. Many in the transect were recently dead after 8 years of growth, during which they reached a height of 4 to 5 ft. *Erica demissa* and *E. chamissonis*, despite initial slowness, grow steadily, have a relatively low mortality rate, and a higher competitive efficiency than either *Cliffortia* or *Anthospermum*.

(3) NITRIFICATION STUDIES.

In view of the slight direct effect of burning, it is considered unlikely to be the cause of that type of increased flowering which may persist for two or three years after burning. It might be responsible for flowering in those plants such as *Cyrtanthus* which flower within 14 days, or those which flower for a few weeks after burning, and do not flower in subsequent years, but for these alternative explanation is possible. This problem should be susceptible to laboratory investigation.

Bacterial activity in a number of Nature Reserve soils was investigated by storing freshly collected sieved soils for 30 days at constant temperatures and moisture content. Nitrates were determined as in Part I (Martin 1964). The samples were classified as unburnt heath, heath burnt in 1951, heath burnt in 1950, heath burnt in 1948, heath cut over in 1951 and heath cut over in 1950. All but one sample were non-nitrifying (Table VI). The one weakly nitrifying sample differed considerably in pH from the other samples, and though it was from a recently burnt soil, it is questionable whether this was a result of burning since no change in pH of this magnitude was observed in the experimental plot of 1950 or any other burnt site. Excluding this sample, no indication of higher rates of nitrification in the burnt area appeared. Culture experiments using ammonium salts and nitrite were continued over several months, but bacterial activity was low. *Azotobacter* could not be isolated from those soils, the pH of which was below 6. The idea that rapid regeneration and flowering in some plants might be a response to increased nitrification seems not to be applicable to this area. That plants may obtain increased supplies of nitrate as a result of decreased competition is not denied.

A close similarity between the effects of burning and clearing was noted. (Plate 3, Fig. 5). Flowering and regrowth are promoted on bare areas cleared naturally by landslides or artificially in making footpaths, and firebreaks, and are less prolific on old firebreaks than on new ones. Nitrification on these sites is also low (Table VI, Nos. 16 & 17). Thus an effect of removal of vegetation seems implicated, rather than any special stimulus produced by fires. This could be either an effect due to removal of competition, or a physical stimulus due to removal of vegetation. Moreover, since regrowth usually proceeds from below ground, any such stimulus must be perceived by the buried parts of the plants.

TABLE VI
Nitrification In Some Burned, Unburned And Cut Heath And Grassland Soils
Stored Sept. 20th—Oct. 14th 1951.

Site & Vegetation Type	Nitrate in p.p.m. d.wt. Initial	Nitrate in p.p.m. d.wt. Stored	H_2O % d.wt.	Loss on ignition % d.wt.	pH
Unburnt Heath					
1. *Erica* heath (soil thermometer site 1)	0·9	1·5	10·2	4·2	5·55
2. *Erica* heath (soil thermometer site 7)	2·9	0·6	14·2	6·0	5·59
3. *Erica* heath (along side No. 17) ..	2·7	0·7	10·5	5·1	5·56
4. *Erica* heath	1·0	1·4	18·9	6·6	5·53
Newly burned area (1951)					
5. Formerly *Metalasia* heath	2·4	8·5	20·8	6·6	6·18
6. Former *Erica-Phylica* heath (site 4)	0·9	0·9	15·3	6·2	5·77
7. Rocky area (site 6)	5·1	3·9	20·9	12·2	5·55
Older burned areas (1948 & 1950)					
8. *Cliffortia—Anthospermum* (site 2) ..	0·7	0·3	9·3	4·1	5·52
9. Experimental Plots (1950) *Cliffortia —Anthospermum*	1·9	2·7	8·8	3·3	5·66
10. *Metalasia*—grass heath	3·7	0·8	19·3	3·9	5·89
11. *Phylica*—tall grass heath (site 3) ..	1·0	1·8	21·8	6·1	5·65
12. Close to site 6 (site 5)	1·1	0·5	15·5	10·6	5·57
13. Grassland on main ridge	2·3	1·2	15·2	4·5	5·94
14. *Anthospermum* heath	1·4	2·1	14·4	3·6	5·99
15. Mixed grass—*Restio* heath (near No. 14)	1·8	2·1	14·6	4·3	5·95
Cut over—unburnt					
16. Fire path around experimental plots	2·6	2·2	7·6	3·5	5·56
17. Path recently cut in *Erica* heath ..	3·3	0·5	14·3	5·6	5·72

(4) SOIL TEMPERATURE MEASUREMENT.

Soil thermometers were installed in suitable sites during the first weeks following the 1951 fires. The thermometers were encased in an outer glass tube with the bulbs in wax, and buried in a horizontal position at 4″ and 1″ depths on burnt and unburnt slopes. The sites were selected for similarity of aspect and slope, depth of soil and stoniness.

The following sites were chosen:—

(1) In unburnt *Erica* at the western end of the Reserve ..	slope ca.12° aspect 212°
(2) In regenerating heath at the western end of Reserve ..	
(3) In regenerating heath, central part of the Reserve ..	Slope ca.22° aspect 135°
(4) In newly burnt heath, central part of the Reserve ..	
(5) In regenerating heath, eastern Reserve	Slope ca.25° aspect 165°
(6) In newly burnt heath, eastern Reserve	
(7) Mature *Erica* heath, western end of Reserve	Slope 22° aspect 212°

Unfortunately, mature unburnt heath and newly burnt heath could not be compared on similar sites, as these no longer existed. Nor could burnt and unburnt sites be compared on north-west facing slopes, for the same reason. Sites

3 and 5, though quite close together, differed in slope, aspect, depth of soil, stoniness and dryness of soil and in plant cover, site 3 being much moister and having deeper, less stony soil and a consequent heavier cover than site 5. Site 4, (Plate 2, Fig. 6), a little lower down the hillside but with the same slope, aspect and soil depth as site 3, was believed to have been dominated by similar vegetation originally (*Erica* spp. and *Phylica* with tall grasses), while site 6, at the same level as site 5 was a similar rocky shallow soil, with the same type of vegetation (*Erica* spp., *Metalasia*, *Psoralea polyphylla* and grasses). Sites 1 and 2 also seemed to be quite comparable. Site 7 in mature *Erica* heath on a 22° slope, facing c. 212°, is most comparable with sites 3 and 4.

Scattered data were obtained in early August, 1951, for afternoons and evenings, indicating that daily maxima occurred before 4.30 p.m., even at 4″ depth. Fluctuation in temperatures were more marked on burnt sites. The necessity for hourly readings was brought out, preferably for a 24 hour period, and this became possible on two occasions. On August 18th and 19th, 1951, under cool conditions of early spring, continuous readings were obtained for all the sites for two periods, one of 12 hours, and one of about 14 hours with a gap of about 10 hours between them. As temperatures were generally still dropping between 6 and 8 a.m. on August 19th it is safe to extrapolate across the gap. On December 1st a similar set of readings was obtained for a period of ca. 16—17 hours under conditions of summer. Unfortunately, all the days chosen were marred by cloud development, leading to a drop in air temperatures before the expected maxima were reached. Rain developed on the night of December 1st, so that a series of readings intended on December 2nd was abandoned.

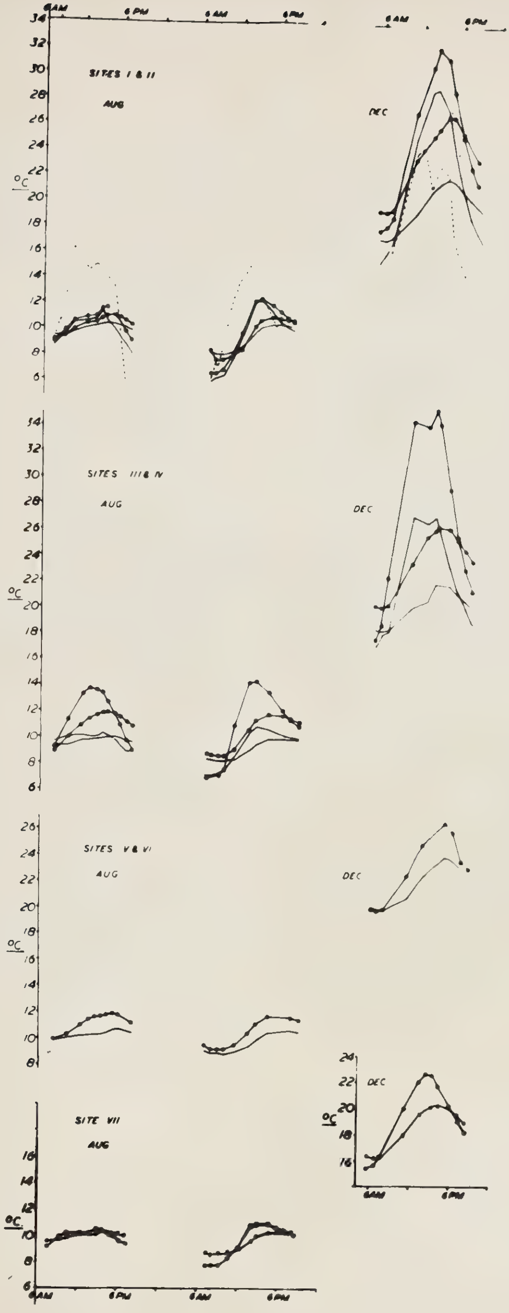
The data are shown in text fig. 7. They show features which are usual in soil temperature curves, for example, the time lag of about 2 hours between the maxima at 1″ and at 4″; a similar lag seems to apply to the minima. The inversions occurring in early morning and late afternoon indicate that at 4″ depth the soil is relatively warmer during the night from about 6 p.m. until 7 or 8 a.m. in summer and from 5 p.m. until 9 to 10 a.m. in early spring.

Features special to these curves are the wide variation both between sites and at individual sites on successive days. On sites such as these with shallow rocky soils, variation due to soil depth, texture, moisture content and other variables must be expected and comparisons are legitimate only when made between the most similar sites.

The differences between mature *Erica* sites and burnt or cleared sites are what chiefly concern us. Despite a few curious features (the very flattened curves

---

TEXT FIG. 7.—Soil temperature runs for Spring (August) and Summer (December) conditions at sites 1 to 7. For explanation refer to text. Sites 5 and 6 had thermometers at 4 in. depth only. Air temperature........


6AM
6PM
6AM
6PM
6AM
6PM
SITES I & II
AUG
DEC
SITES III & IV
AUG
DEC
SITES V & VI
AUG
DEC
SITE VII
AUG
DEC
°C
34
32
30
28
26
24
22
20
18
16
14
12
10
8
6

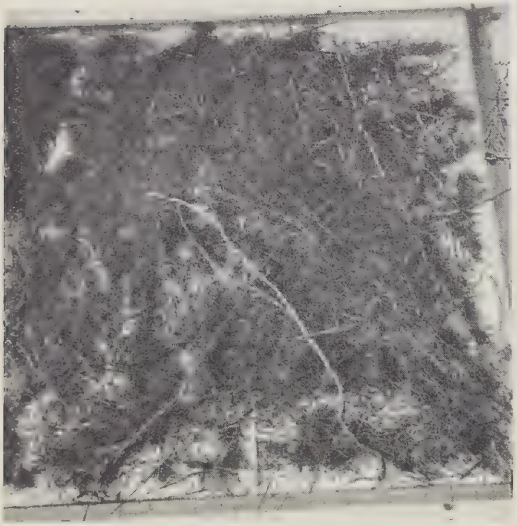


FIG. 4.
Brushwood and litter from one metre square on cleared plot. Dryweight 1020 gms.

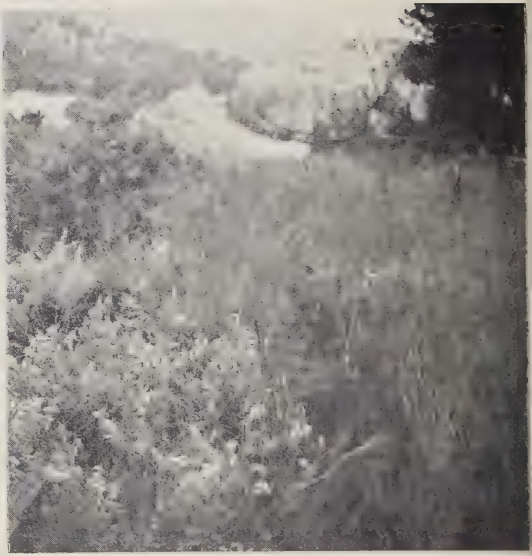


FIG. 5.
Firepath effect. Mixed heath on left dominated by *Erica demissa* and *E. chamissonis* represents parent community. Pure *Cliffortia linearifolia* community on right is product of superficial clearing with incomplete removal of rootstocks.

Plate 2.

obtained on August 18th at all sites, compared with the more expected curves on the 19th, probably owe their character to some feature of the previous day's weather), the general character is the same throughout. In August a mature *Erica* soil reaches a maximum of 10·5°C at 4″ and up to 12°C at 1″, while adjacent regenerating heath reaches maxima of 11°C and 12·5°C respectively.

On newly burnt heath (site 4) maximum temperatures at 4″ were as much as 12°C and at 1″ 14·5°C, while in adjacent regenerating heath temperatures were 10°C and 12°C respectively. Site 7, unburnt, closely comparable with these, showed maxima of 10·5° and 11°C respectively. Minima likewise are lowest on burnt sites, 7°C on site 4 compared with 8°C on site 7. Sites 5 and 6 on steep slopes show similar features; maxima at 4″ depth being ca. 1°C higher on newly burnt than on adjacent regenerating heath, though minima are similar.

Thus as far as the evidence goes, one may judge that even in early spring greatest extremes of temperature are experienced on burnt sites, next greatest on regenerating sites and least on mature heath sites. These results are to be expected and it is well known that vegetation cover decreases heat flow and therefore damps fluctuations of this sort. It is interesting to note that the differences in maxima at this time of year are only of the order of 1 or 2 degrees. Taking the daily range, the fluctuations between minima and maxima are of the order 5 to 7°C at 1″ at burnt site 4, and about 3·5°C on the adjacent site 3. On the other hand, mature heath and regenerating heat at sites 1 and 2 show very similar curves with daily fluctuations of about 6·5°C in each case on August 19th. It is clear that individual sites may vary considerably on account of differences in soil depth and humidity. Sites 1 and 2 are clearly drier than sites 3, 4 and 7 (Table V) and should not therefore be compared directly with them.

In summer the differences are much more extreme, the daily fluctuation at 1″ being least at site 7 (8°C), then site 3 (10°C) and site 1, the driest and most

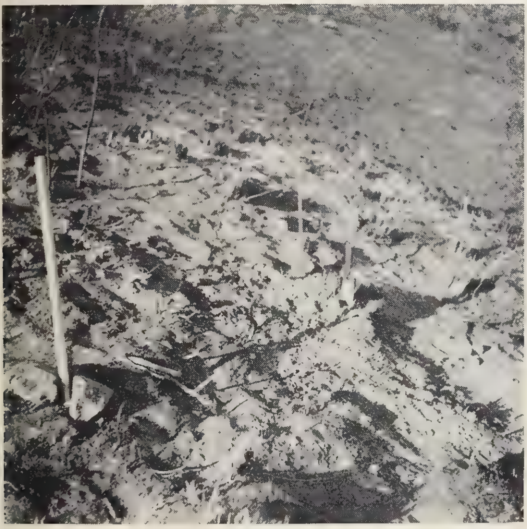


FIG. 6.
Soil thermometer site no. 4 in burnt area on 22° slope. showing general appearance of heath a few days after burning.

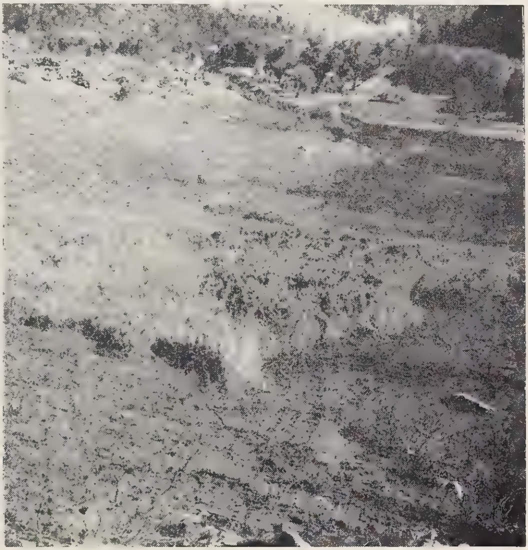


FIG. 7.
Result of 1955 fire. Island of unburnt heath, of which the left-hand side was burnt in 1948 and the right hand side about 1933. The dark colour of the 1955/33 burn in comparison with the 1955/48 burn is largely due to greater density and height of the still standing brushwood (mainly *Erica*), but also to the comparative scarcity of regenerating grasses (left foreground). Note tree composite *Oldenburgia arbuscula*, which survived fire on rocky ridge in background. The Pine trees in distance are outside the Reserve.

Plate 3.

exposed, (13·5°C). On regenerating heath (site 2), the fluctuation was 15°C and on recently burnt heath (site 4) 18°C. At 4″ depth, unburnt heath fluctuated less (3·5 to 5°C) compared with recently burnt (6 to 7°C), while on regenerating heath the more exposed site 2 fluctuated 7°C and less exposed site 5 fluctuated 4·5°C.

DATA RESULTING FROM THE FIRE OF 1955

The disastrous fire of August, 1955 was one of the most severe ever known in the Grahamstown district. Many square miles of heath, grass and plantation in the Grahamstown hills were destroyed. The extensive woodlands of Eucalypts, and self sown pines and Australian wattles were burnt right to the outskirts of the town. The whole of the heath and grassland of the Nature Reserve was burned. However, the natural forest and scrub, as in previous fires, escaped with marginal injury. In one or two places, roots ignited and smouldered for several days, spreading many yards into the forest with some consequent burning of litter, but no single area of natural forest was destroyed or even seriously burnt back, since the main components of the forest margin, *Rapanea melanophloios*, *Tarchonanthus camphoratus* etc. regenerate well by epicormic shoots (Plate 1, Fig. 3).

The experimental plots which had been last examined in 1952, were burnt shortly before they were due to be replotted. Further, since almost the whole of the remaining *Erica* heath was destroyed, the further development of heath in the Reserve could scarcely be compared with the past development, as no major seed sources remained within several miles.

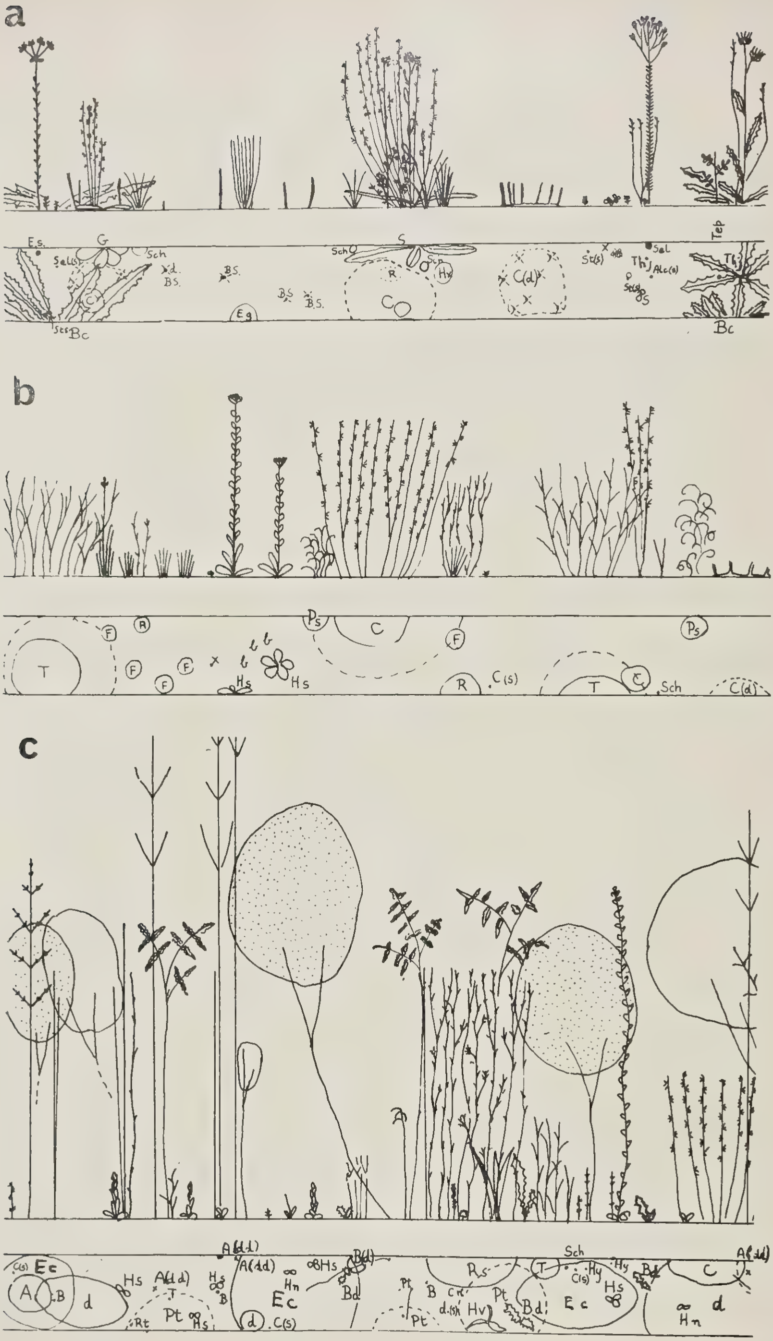
Luckily, reburning on the 1951 burn was, predictably, slightly patchy and a few small clumps of regenerating heath plants escaped burning. Thus a small number of *Erica* seed foci remained in the Reserve, though they were now for the most part single isolated plants. In addition, chance had left one roughly lozenge shaped area of unburnt heath straddling the margin between the regenerating heath burnt in 1948 and the unburnt heath. This is indicated diagrammatically in text fig. 1 and depicted in Plate 3, Fig. 7. Unfortunately, as the author was leaving Grahamstown in 1956, the most could not be made of this opportunity of studying the stages of regenerating in detail within one small relatively uniform area. However, a belt transect 6″ wide was run through the widest point of the lozenge and portions of this were plotted to scale on graph paper, showing the height and projective cover of all plants crossing the strip. A second transect crossing directly from the 1955 burn into the 1948 burn above the heath had to be abandoned through lack of time.

In Text fig. 9 which shows part of the results from the transect, arbitrary units are used, multiplying the projective cover by a factor derived from the height of the plant. Plants are grouped into six height classes (1) 0—2″, (2) 2—4″, (3) 4—8″, (4) 8—16″, (5) 16—32″, (6) > 32″. Thus a plant of projective cover 12 sq. inches as measured with graph paper, and 9″ high scores 48 units. In this way values were obtained which are related to herbage mass. Doubtless, plants of different life forms may have the same projective cover and height but a different herbage mass, but it is assumed here that for each species a series of values obtained in different years will give an indication of actual changes in herbage mass and hence of proportion of total plant mass in the community. This rather laborious method was resorted to as it was not deemed advisable to cut and dry-weigh the vegetation when so little undisturbed heath remained. It is assumed that the succession in space here also represents approximately the succession in time. Values are thus available for 0 years (1955), 1 year, (1956) 8 years (1948 burn plotted in 1956) and (?) 20 years in mature unburnt heath, as well as the twice burnt (1948/55) vegetation. Small strips of the transect plotted in elevation and plan are shown in Text fig. 8.

Some reservations must be made about the meaning of the graph. For instance, *Anthospermum aethiopicum* plotted in the eight year old heath was tall (up to 48″ high) but mostly dead. It is clear that it reached its maximum cover a few years previously. The units attributed to Anthospermum in the 8 year old heath include only the living plants, the dotted line (A) represents the estimated units attributed to *Anthospermum* on the assumption that the dead plants had reached their maximum size in 1954.

The role of *Pteridium* in this transect is anomalous. Living plants were found only in the 8 year old heath. As *Pteridium* is seldom killed by burning at 8 year intervals, its absence in the area of the 1955 burn is most probably another phenomenon of overdispersion, i.e. its presence only in one part of the transect is fortuitous. *Pteridium* is therefore not considered further in this study.

The features which stand out most clearly are (*a*) Forbs reach their maximum vegetative mass in the first year or two after burning. (*b*) *Cliffortia* goes on increasing and appears to be close to its maximum at 8 years (probably a little earlier as the 8 year *Cliffortia* are already becoming leggy. (*c*) *Anthospermum* reaches its maximum between 1 and 8 years, probably between 4 and 6 years after burning and thereafter begins to die out. (However, seedlings develop and *Anthospermum* remains a component of the mature heath, though rather a minor one). (*d*) Gramineae are not important in the one year old burn of mature heath, nor do they assume importance later, though they are more conspicuous at 8 years than in mature heath. (*e*) *Erica demissa* and *E. chamissonis* seedlings first appeared in 1956, 1 year after the fire. Their mass is negligible at this stage as most are only ¼″ high. *Erica* appears to increase steadily in dominance to the mature heath. It is interesting that from 8 to 20 years, % bare ground appears to remain constant. *Erica* is increasing at the expense of its competitors during this period. The few other shrubs which enter include *Rhus fastigiata*, *Burchellia*


a
Es.
G
Sel(s)
Sch
d.
BS.
BS.
BS.
BS.
Eg
Sch
S
R
Hx
C
C(d)
St(s)
Sel
Th
Alc(s)
Tep
Th
Sts
Bc
Bc
b
F
R
Ps
C
F
T
F
F
F
Hs
Hs
R
C(s)
T
C
Sch
C(d)
Ps
c
C(s)
Ec
A
B
d
Hs
A(dd)
T
Rt
Pt
Hs
Hs
B
A(dd)
Hn
Ec
d
C(s)
Hs
B(d)
Bd
Pt
B
Cr
d.(s)
Hv
Pt
Rs
Sch
T
Hy
C(s)
Hy
Hs
Bd
Bd
Ec
C
A(dd)
d
Hn

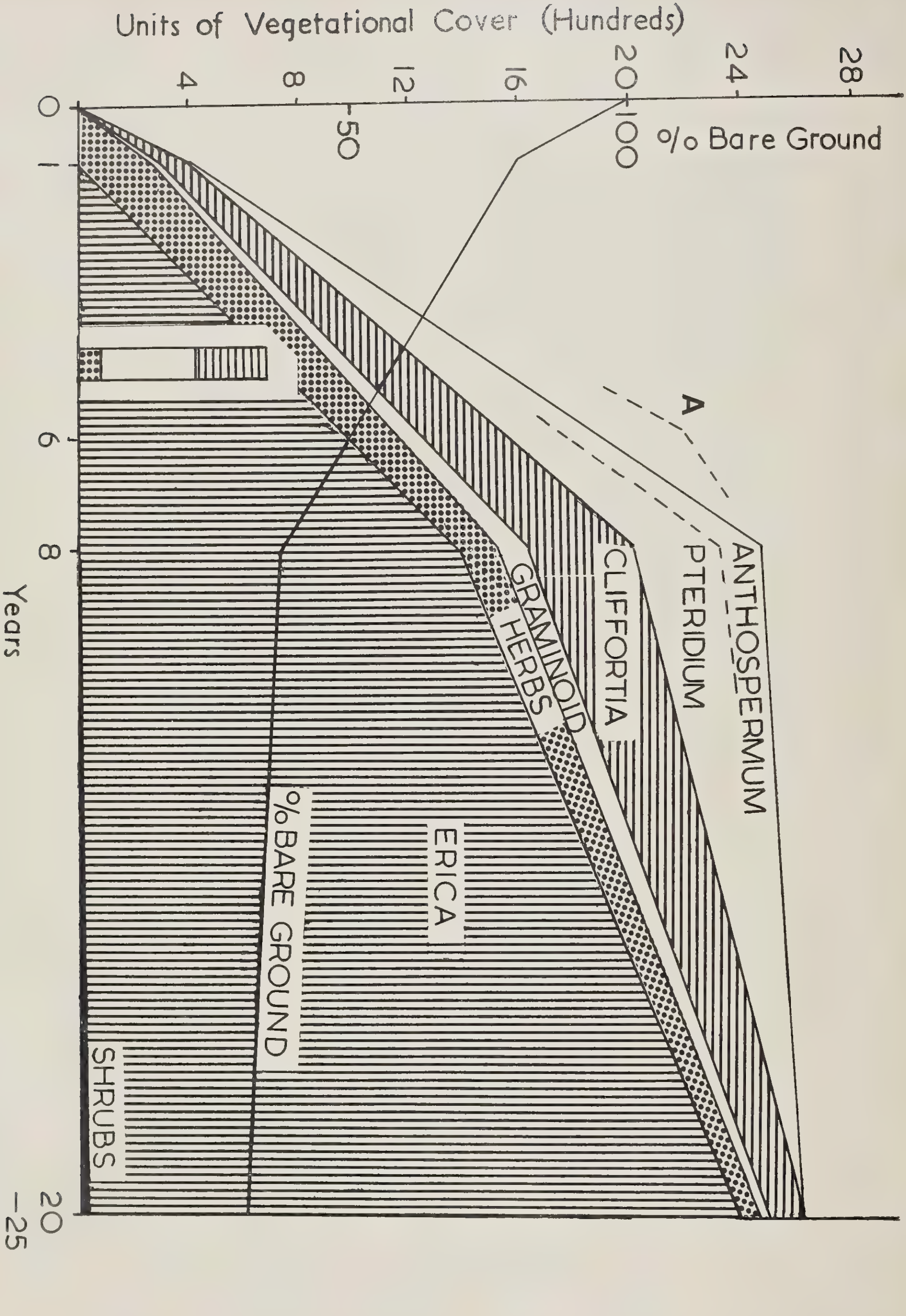
bubalina, *Myrsine africana*, *Psoralea spicata* and *Metalasia muricata*. Though apparent to the eye, they make very little showing in the transect.

The twice burnt heath has a very different appearance from the once burnt, though it is presumably derived at least in part from the community of which the 8 year regeneration heath forms the surviving example. The role of forbs is surprisingly much less and that of *Cliffortia* and grasses much more than in the 1 year old burn. The reason is perhaps that in the period 6—8 years after burning, grasses and *Cliffortia* reach their maximum cover, thus burning at this stage catches *Cliffortia* at a high level of physiological efficiency. Burning at 20 years finds *Cliffortia* in a senescent state. Perhaps the same is true of grasses, many of which seem to regenerate from subterranean buds rather than from seeds. The same argument cannot be applied to forbs, for if they are degenerate at 8 years, they should be even more so at 20 years, yet their regrowth from subterranean rhizomes and stocks in a vegetation type in which the above ground parts are scarcely apparent, is remarkable. One possibility is that we are dealing with a further case of non-random distribution. It is on this point that the second transect through the direct transition from once burnt to twice burnt heath could have thrown light. All that can be said is that the greater abundance of grasses in the twice burned area made the transition sharp even here (Plate 3, Fig. 7). It is probable that *Helichrysum* spp., especially *H. subglomeratum*, were fortuitously more abundant in the twice burnt area and that *Berkheya* spp. in the once burnt, and it may be that the apparent decrease in forbs is simply a product of the difference in rosette size of these spp. and the mode of representation employed, the rosettes of *H. glomeratum* being generally smaller, though it reaches the same flowering height.

DISCUSSION

The effect of fires on nanophanerophytic vegetation ("heath", "brush", "macchia", "sclerophyll scrub") has been described for many parts of the world. In the majority of cases, a marked increase in herbaceous cover, sometimes including grasses, has been reported. Jarrett and Petrie (1929) reported a prolific production of seedlings of both woody and herbaceous species in S.E. Australia. Pritchard (1951) upheld the view that fire should be regarded as part of the natural environment and is responsible for preserving species diversity in plant communities, especially as regards the herbaceous flora. The behaviour of chaparral has been discussed by Sweeney (1956) who reported numerous species

TEXT FIG. 8.—Specimen section of 6″ belt transect plotted 1956 (*a*) burnt in 1955 after ca. 20 years of growth. (*b*) burnt 1948 and 1955. (*c*) burnt 1948 and showing 8 years regeneration. For corresponding transect in heath unburnt ca. 20 years see Pt. I (Martin 1964). Symbols in addition to those in text fig. 5 and Table IV: b = *Bryum* sp., B.S. = burnt stump (unidentified), E.s. = *Euphorbia striata* Hx = *Harpechloa falx*, Rs = *Restio sejunctus*, Sel = *Selago corymbosa*.


Units of Vegetational Cover (Hundreds)
4
8
12
16
20
24
28
50
100
% Bare Ground
0
1
6
8
Years
20
–25
A
ANTHOSPERMUM
PTERIDIUM
CLIFFORTIA
GRAMINOID
HERBS
ERICA
% BARE GROUND
SHRUBS

of annuals regenerating by means of dormant seeds surviving fire in the soil. He investigated the heat penetration of soil and the germination behaviour and heat tolerance of seeds, concluding that the vast majority of plant seedlings in chaparral burns are from viable seeds already in the soil when the fire occurred He endorsed the findings of Pritchard and further concluded that the occurrence of herbaceous plants on burns is as characteristic of sclerophyll bush regions as are similarities in physiognomy of the woody cover. His findings differ from those in Eastern Australia however, where many of the seedlings are those of shrubs shed onto the ground subsequent to burning by species actually burnt in the fire but possessing refractory fruits (e.g. *Hakea* spp.), and from both South Africa and Australia, where annuals are of minor importance.

Adamson (1935) for the S.W. Cape region of South Africa reported only a weakly enhanced representation of annuals following fire in sclerophyll. He also reported the prolific increase of perennial shrubs (among them *Anthospermum aethiopicum*) for the first few years after fire.

The heath of the Grahamstown Nature Reserve is of a type generally classified as belonging floristically and physiognomically to the Cape "Sclerophyll" vegetation type of nanophanerophytic shrub heath. It exists under a rainfall of 25—30″ p.a. with weak spring and autumn maxima. The present investigation differs from those of most other investigators in finding that the greater portion of the species becoming prominent and flowering soon after fire are hemicryptophytes, which actually survive burning by means of buds close to the ground surface. Geophytes and some chamaephytes (geoxylic hemixyles) also play a part in this regeneration but annuals are practically absent; plants regenerating from buried seed are mainly shrubs which only begin to become prominent in the second year after burning, while the seeds of the species which ultimately assume dominance are borne into the burnt area by wind. Such a type of behaviour by hemicryptophytes suggests that soil surface temperatures must be very low during fire, or that such plants are facultative geophytes. Both eventualities seem to be possible. Soil temperatures even $\frac{1}{2}''$ below the surface remained below 50°C in the experimental plots and a general survey suggests that this is quite usual. Story (1952) reports grasses regenerating from the base in *Erica brownleeae-Cliffortia paucistaminea* heath on the Amatola Mountains. This type of heath is taller, denser and produces a greater amount of inflammable brushwood than the Grahamstown heath, yet soil temperatures appear to remain relatively low. Recently Whittaker (1961) has made a similar report on North British Callunetum, which though not directly comparable with the

---

TEXT FIG. 9.—Herbage changes occurring in regeneration of heath after fire, using height—projective area data of type shown in text fig. 8 (see text). Inset = composition in 1956 of heath burnt 1948 and 1955.

community under review, seems to achieve the same range of surface temperature while burning. Cook (1940) records quite low subsurface temperatures from grassland burns in the Transvaal. The efficient insulation properties of even ½" of soil seem to be firmly established. Coupled with this are the adaptive life forms of some of the plants involved. *Helichrysum subglomeratum* and *Berkheya* spp. produce rosettes and short stolens or suboles which form new rosettes clustered round the initial plant. *Acalypha peduncularis* can behave facultatively as a hemicryptophyte or geophyte, and this probably applies to *Clutia heterophylla* which is structurally classified as a chamaephyte.

The belief of Sweeney (l.c.) that herb regeneration, like physiognomy, is a characteristic of the vegetation type requires qualification therefore. The precise form taken by herb and shrub regeneration may vary. In Australia, with its preponderance of woody-fruited Myrtaceae and Proteaceae, seed is commonly shed onto the soil after fire. In California the majority of herbs and shrubs seem to regenerate from seeds present in the soil. In South Africa Proteaceae behave much as in Australia. Most other shrubs regenerate from woody rootstocks or other subterranean parts, from seeds already in the soil or (in Ericaceae) by light seed blown into the area. The presence of lignotubers is frequent in Australia, occasional in South Africa and otherwise seems to be rare. Herb regeneration by seed is rather uncommon and annuals are practically absent in the Grahamstown heath investigated here. In these respects the Grahamstown heath is most comparable with the heath of the S.W. Cape.

The question of the status of heath requires some discussion. In Part I of this study *Erica demissa* heath is recognised as one climax type of the Witteberg region. The present study seems to confirm this from a consideration of the behaviour of *Erica demissa* after burning. The gradual assumption of dominance after burning is a process taking a period of about 10 years and the community is fully mature at 20—25 years of age. Story arrives at a very similar conclusion for the *Erica brownleeae-Cliffortia paucistaminea* community of the Amatolas, which in many respects resembles the *E. demissa-C. linearifolia* heath. The abundant herbaceous plants and chamaephytes in this heath can be interpreted in two ways. Either they represent a natural part of the vegetation which, however, is dependent on recurrent fires for its continued existence, or they may represent a former vegetation type invaded by heath and now present only as relicts. Most investigators of this type of vegetation have come to the former conclusion, either from a study of the life forms or from the succession. Thus Story (l.c.) reporting on the experimental enclosure made by Schonland in the Amatolas in 1922 and re-examined at intervals until 1949, concluded that *Themeda* grassland and *Helichrysum* veld were in seral relation to *Erica brownleeae-Cliffortia* "macchia", and that fire or grazing were responsible for preventing the spread of heath spp. Sweeney (U.S.A.) and Pritchard (Australia) as quoted above, consider that fire must be regarded as entirely natural to these communities and that it is chiefly responsible for preserving the herbaceous flora which would otherwise become very much reduced. Wicht (1945) reached similar conclusions for the Cape flora.

Acocks (1953) appears to arrive at the opposite conclusions. His views on "fynbos" or "macchia" are only very briefly expressed, but from his maps 1 and 2 and the statement (l.c. pp. 14—15). "The fynbos shows the biggest movement of all, having spread from the neighbourhood of Bredasdorp, Montagu and Touws River to Grahamstown. It is now invading the Amatola Mountains", together with the following paragraphs, it appears that he believed the heath or fynbos of the Eastern Cape Province to be a "false macchia" i.e. one owing its existence to human interference. The comparison of maps 1 and 2 does not, however, literally express Acocks' belief. It is clear that patches of fynbos too small to be plotted on this scale could, in Acocks' view, always have existed east of Bredasdorp and Montagu. On no other basis could one account for the widespread endemism of heath species in areas as far east as Grahamstown.[1]

The views arrived at in this paper are that the biological behaviour of *Erica demissa* and *E. chamissonis* is consistent with their interpretation as climax vegetation; that they and other heath dominants are not aggressive species likely to spread after human interference but rather the contrary; that the species diversity of the heath is not incompatible with the natural dominance of *Erica* and that the most reasonable explanation of the complex adaptive and adaptable life forms of many of these species is that they have evolved over many thousands of years under conditions in which natural selection has acted to conserve the most fire-tolerant adaptations. If *Erica demissa* and *E. chamissonis* are invading grassland following interference, it seems unusual that the adult plants unlike many of their competitors fail to regenerate from the base after cutting or burning, that the species are sensitive to drought, and especially that burning at more frequent intervals leads to increased abundance of grasses and extensive destruction of the *Erica* spp. The type of community promoted by repeated burning is one in which Gramineae, herbs and small geoxylic shrubs are all prominent. Communities of this type in the Nature Reserve have been described in Part I as Grass Heath.

---

[1] Acocks (in lit. 1965), has offered very convincing reasons for believing that much of the heathy vegetation of the Eastern Cape is, in fact, "False Macchia", produced mainly by the agricultural methods of the past one and a half centuries. While agreeing with Acocks for some areas, and agreeing too, with much of the suggested mechanism, I consider the area described in this paper to have more of the character of a natural focal area from which indeed, some species now common in false macchia may originally have spread. It is clear that we both agree such focal areas must have existed. A history of false macchia for the Reserve and similar areas is rebutted. It is not claimed that the vegetation of the Reserve under observation in the period 1932-56, represents totally unmodified climax. It is, though, as nearly unaltered as we are likely to find, as is shown for instance, by the scarcity of so many false macchia species, e.g. *Elytropappus rhinocerotis*, of which only one or two plants were found on the Reserve, on obviously disturbed ground.

In terms of Whittaker's (1953) concept of the climax, the mosaic of communities in the area is a single climax pattern, with seral stages and various climax communities mixed, the varying degree of biotic influence forming a feature of the pattern. On the view of Tansley (1935), the *Erica* heath would probably be singled out as a climax type and the fire derived communities regarded as sub-climax communities of various sorts. Clement's terminology too, would regard the *Erica* heath as climatic climax, forest being postclimax, and grass heath a biotic dis-climax. There remain on the Reserve small areas of almost pure grassland, described in Part I, and it is clear that they do not fall among any of the communities described in this paper. At present the status of these communities cannot be decided. They may represent the effect of intensified grazing, either alone or with clearing. The fact that these grassy areas occupy some of the flattest ground in the Reserve may be significant, and it would be interesting to know more about the land utilisation and sites of buildings, kraals, etc., on the Reserve in the eighty years when it was used as farm land before it became commonage.

The third point of discussion—the nature of the stimulus to flower—is one about which no clear conclusions can be reached. In removing vegetation too many factors are changed for a field experiment to give a clearcut answer. Competition effects, temperatures and light effects, soil physical, biotic and chemical characteristics, may all be changed, some at once, some gradually.

In the present study, attention has been concentrated on certain types of response and on one particular stimulus, and it is suggested that irrespective of the precise temperature fluctuations involved, the change in diurnal rhythm after burning is one of the most important factors, if not the one major factor in the flowering behaviour of fire herbs such as *Cyrtanthus contractus*. These bulbous plants behave as if "triggered" by a simple release mechanism, and it is thought that in view of the quite small ephemeral temperature increases experienced at the depth of the bulbs, it is more likely to be the sudden change in daily temperature fluctuation that is perceived in what Sweeney calls a simple "stimulus-response relationship". Most other species affected by fires behave in a distinct seasonal pattern, similar in many cases to that which they show in unburnt heath. For these plants it is much more difficult to decide whether competition alone or soil temperature differences alone or some combination of these two, or even other stimuli, could be responsible. In a recent paper Specht (1963) has shown that phosphatic fertilisers may lead to increased and earlier flowering in S. Australian heath as well as an increase in herbaceous cover. The amount of phosphate liberated by burning of *Erica*, like that of nitrate, must be too negligible to produce the observed effects, but the removal of competition for soil phosphate by roots of the dominants may be having somewhat the same effect on subordinate vegetation as fertilisation would have. It is, however, suggested that the possible role of increased diurnal temperature range and the generally higher daily maxima could be important and that these are factors often neglected in favour of competition.

CONCLUSIONS

1. The prolific flowering occurring after heath fires in the Grahamstown hills is due almost entirely to shooting from subterranean parts of surviving herbaceous plants.

2. The rapid transit of fire through heath, together with the insulatory properties of soil, results in only a momentary rise in surface temperature to above 500°C at any one spot, while temperatures at even $\frac{1}{2}''$ depth may remain below 50°C. Under these circumstances, perennating organs of plants can easily survive close to the soil surface.

3. Annual plants, regenerating from refractory seeds, often prominent in similar vegetation types elsewhere, are unimportant. Seedlings which appear in the first year after fire are mainly those of relatively slow-growing shrubs and perrenial herbs, e.g. Leguminosae (Table III).

4. Flowering in the months following fire is in a definite order, repeated with little variation after each fire observed. This order is observed also in succeeding years though the abundance of flowering may fall off more or less gradually.

5. The same type of response is produced following clearing, suggesting a common stimulus in both sets of conditions. Addition of ash following fire is thus excluded as a major cause of flowering. Removal of competition, increased soil temperatures and increased diurnal temperature ranges are considered as possible causes. The flowering of "fire lilies" immediately after fire is considered to be a direct stimulus-response relationship, the putative stimulus being the changed rhythm of diurnal soil temperature fluctuations.

6. Any increase in nitrification following burning or clearing is regarded as negligible. pH changes are also negligible and variable.

7. Geoxylic shrubs, especially *Cliffortia linearifolia* survive fires and become temporarily dominant for a few years, later assuming a subordinate position becoming tall and apparently senescent.

8. A second group characterised by the aeroxylic *Anthospermum aethiopicum* and *Selago corymbosa* is destroyed by fire and regenerates from seeds present in the soil. *Anthospermum* also has a period of maximum importance in the regenerating heath and subsequently becomes a minor component.

9. A third group consisting of aeroxylic *Erica demissa* and *E. chamissonis* is destroyed by fire and regenerates entirely from light seed borne into the area subsequent to the fire. These two species under good conditions assume dominance by about 8 years after fire and subsequently are at a competitive advantage over all other heath components, through their production of a dense cover and extensive shallow root systems.

10. These species of *Erica* are sensitive to drought, do not seed well under drought conditions, and seedlings do not usually appear on a burnt site in the spring following a winter burn but late in the following spring. In drought conditions their appearance may be delayed.

11. Heath once burned will not readily burn again for several years. Burning of immature regenerating heath proceeds with difficulty and patchily, due to the incomplete cover and low supply of fuel. A very similar effect has been obtained experimentally in mature heath by complete removal of dry brushwood and litter.

12. Repeated burning of heath at relatively short intervals leads to a predominance of geoxylic shrubs and grasses and the total elimination of *Erica demissa* and *E. chamissonis*, resulting in the establishment of a "grass-heath complex".

13. On the other hand, prolonged absence of fire must result in some herbaceous spp. and possibly some shrubs becoming rare or disappearing. Irregular occurrence of fires appears to be essential to the maintenance of a diversified flora.

14. For the maintenance of the natural flora in the Grahamstown Reserve and Grahamstown Hills, the present trend towards more frequent (but probably more patchy) fires should be reversed, but no special effort to prevent fire completely need be made. On the other hand burning of very large areas at a time is disadvantageous for re-establishment of *Erica demissa* and *E. chamissonis*. Contained burning of heath at average intervals greater than 8—10 years, but not necessarily in excess of 20 years, seems to be consonant with the maintenance of all components of the present flora. These views are in general accordance with Wicht (1945).

15. The flora is regarded as having evolved over a long period in equilibrium with such an average fire interval. This conclusion is contrary to the suggestion that heath in Central Albany is a secondary community or "false macchia" which has replaced natural grassland.

ACKNOWLEDGEMENTS

I am indebted to Mr. R. Story, formerly Government Botanist at Grahamstown, for the identification of grasses, for the loan of a graduated 1 m. quadrat frame, and for helpful discussion at all times, and to the Departments of Physics and Chemistry, Rhodes University, for the manufacture of the thermocouple and for the loan of thermometers respectively.

Miss Janne Iansen and Miss Susan Dickson, Botany Dept., University of Sydney, are thanked for typing the manuscript. I am much indebted to my wife for assistance with fieldwork.

References

Acocks, J. P. H. 1953. Veld types of South Africa. *Bot. Survey S. Afr. Mem.* No. 28, 192 pp. Govt. Printer, Pretoria.

Adamson, R. S. 1935. The plant communities of Table Mountain. III. A six year study of regeneration after burning. *J. Ecol.*, **23:** 44–55.

Beadle, N. C. W. 1940. Soil temperatures during forest fires and their effect on the survival of vegetation. *J. Ecol.*, **28:** 180–92.

Cook, L. 1940. A contribution to our information on grass burning. *S. Afr. J. Sci.*, **36:** 270–82.

Jarrett, P. H. and Petrie A. H. K. 1929. The vegetation of the Blacks' Spur region. II. Pyric succession. *J. Ecol.*, **17:** 249–81.

Levyns, M. R. 1935. Germination in some South African seeds. *S. Afr. J. Bot.*, **1:** 161.

Martin, A. R. H. 1964. The plant ecology of the Grahamstown Nature Reserve. I. Primary communities and plant succession. *S. Afr. J. Bot.*, **31:** 1–54.

Pritchard, E. W. 1951. Bush fires as an ecological factor in the preservation of the natural flora. *S. Aust. Nat.*, **26:** 32–4.

du Rietz, G. E. 1931. Life forms of terrestrial flowering plants. *Act. Phytogeog. Suec.*, **3:** 1–95.

Specht, R. 1963. Dark Island Heath, Ninety Mile Plain, South Australia, VII. The effect of fertilisers on composition and growth 1950–60. *Aust. J. Bot.* **11:** 67–84.

Story, R. 1952. *A Botanical Survey of The Keiskammahoek District.* Bot. Survey. S. Afr. Mem. No. 27, 184 pp. Govt. Printer, Pretoria.

Sweeney, J. R. 1956. Responses of vegetation to fire. A study of the herbaceous vegetation following Chaparral Fires. *Univ. California Publ. Bot.*, **28:** 143–249.

Tansley, A. G. 1935. The use and abuse of vegetational concepts and terms. *J. Ecol.* **16:** 284–307.

Whittaker, E. 1961. Temperatures in heath fires. *J. Ecol.* **49:** 709–16.

Whittaker, R. H. 1953. A consideration of climax theory: the climax as a population and pattern. *Ecol. Monog.* **23:** 41–78.

Wicht, C. L. 1945. Report of the committee on the vegetation of the South Western Cape. *Spec. Publ. Roy. Soc. S. Afr.* 56 pp. Cape Town.

STAPELIEAE FROM SOUTH TROPICAL AFRICA, II

L. C. Leach & D. C. H. Plowes

The identities of *Huernia kirkii* N. E. Brown and *H. hislopii* Turrill have long been confused; it is the purpose of this paper to clarify the whole position with regard to these and several other closely related taxa. *H. longituba* N. E. Brown and the subspecies from Cashel, S. Rhodesia are included as both have, at times, been confused with other members of the complex.

It has been stated by various authors that the intermediate lobes of *H. kirkii* are exceptionally large and are spreading or reflexed also that the lower part of the tube is marked within with broken concentric lines of colour on a cream ground.

Neither of the above characters is even mentioned by N. E. Brown and examination of the type disclosed no apparent trace of any lines within the tube while the intermediate lobes are very small. However, included in Turrill's original description of *H. hislopii*, are both lined tube and reflexed intermediate lobes.

The distribution of *H. kirkii* has been considered to extend to the vicinity of Bulawayo in S. Rhodesia; yet this species does not occur in this area but *H. hislopii* is comparatively common among the granite hills of the Matopos while *H. hislopii* subsp. *robusta* is quite frequent in the thorn bush and *Mopane* veld of the Bulawayo and Nyamandhlovu Districts.

The original description of *H. kirkii* clearly indicates a bicampanulate corolla; now that more material of *H. bicampanulata* Verdoorn has accumulated and become available for study, it appears that the distinctions drawn between that species and *H. kirkii* have all broken down. It seems therefore, that *H. bicampanulata* is synonymous with *H. kirkii* and that the apparent rarity of the latter species was due largely to the fact that the majority of later gatherings have been referred to *H. bicampanulata*.

Further complications were introduced when the identity of *H. hislopii* was confused with that of an, until now, undescribed species; this error caused *H. hislopii* to be accepted as an extremely variable species. The reversal of the keys in respect of *H. kirkii* and *H. hislopii* in both White & Sloane and Luckhoff also added to the confusion.

It appears therefore, that these misconceptions have arisen because of various incorrect interpretations of both *H. kirkii* and *H. hislopii*; the subsequent continuance of these misconceptions was, no doubt, all the more readily accepted bacause of the relatively common occurrence and apparent variability of *H. hislopii*, coupled with the apparent extreme rarity of *H. kirkii*.

The conclusions set out herein are drawn very largely from observations made of relatively large numbers of plants, both in the field and in cultivation over a period of several years. It has been noted that considerable as the variation within a community may be, individuals are (except for size of flower) remarkably constant and have remained so in cultivation over a number of successive flowerings.

A key to the taxa in the *H. kirkii* complex.

I. Inner corona lobes clavate.
  A. Intermediate corolla lobes small (normally less than 1·5 mm. long); inner corona lobes usually somewhat recurved at the apex; papillae subulate up to 1·5 mm. long.
    (i) Corolla lobes usually wider than long; tube not at all or only very obscurely concentrically lined within (usually uniformly dark purple); papillae rather slender, usually with a short acute mucro, sometimes with a short bristle; stems 4/5-angled .. .. .. *H. kirkii*
    (ii) Corolla lobes ± deltate, ± as long as broad; base of tube distinctly concentrically lined; papillae slender, with an acute mucro.
      (*a*) Papillae without setae; stems 4/5-angled.. .. *H. longituba*
      (*b*) Papillae usually with setae; stems 5/6-angled. *H. longituba* subsp. *cashelensis*
  B. Intermediate corolla lobes large (c. 3 mm. long); inner corona lobes subclavate suberect; stems 5/7-angled .. *H. hislopii* subsp. *robusta*
II. Inner corona lobes not clavate.
  A. Intermediate corolla lobes large (c. 3 mm. long); inner corona lobes suberect, ± subulate; papillae stout, subclavate or obtuse, much widened at the base, up to 1·5 mm. high.
    (i) Corolla lobes longer than broad, markedly attenuate; tube distinctly concentrically lined inside the globose-ampliate base, the throat shorter than the inflated portion; stems almost invariably 5-angled *H. hislopii*
    (ii) Corolla lobes as long as or not very much longer than broad, attenuate but not very markedly so; tube only slightly ampliate, very obscurely lined within, the throat at least as long as the ampliate portion .. .. *H. hislopii* subsp. *robusta*

B. Intermediate corolla lobes small (up to 2 mm. long).
   (i) Papillae slender, subulate; corolla lobes ± deltate, ± as long as broad; tube distinctly concentrically lined within; inner corona lobes obtuse, somewhat recurved.
      (*a*) Papillae without setae; tube not at all ampliate; stems 4/5-angled .. .. *H. longituba*
      (*b*) Papillae usually with setae; tube often very slightly ampliate; stems 5/6-angled .. .. .. *H. longituba* subsp. *cashelensis*
   (ii) Papillae very short, conical; inner corona lobes stoutly subulate, mounted low down on the staminal column with the base almost touching the outer corona; tube short, ± cylindric, shining dark purple within (no lines); stems long and slender (always less than 1 cm. diam.), 5-angled .. .. *H. occulta*

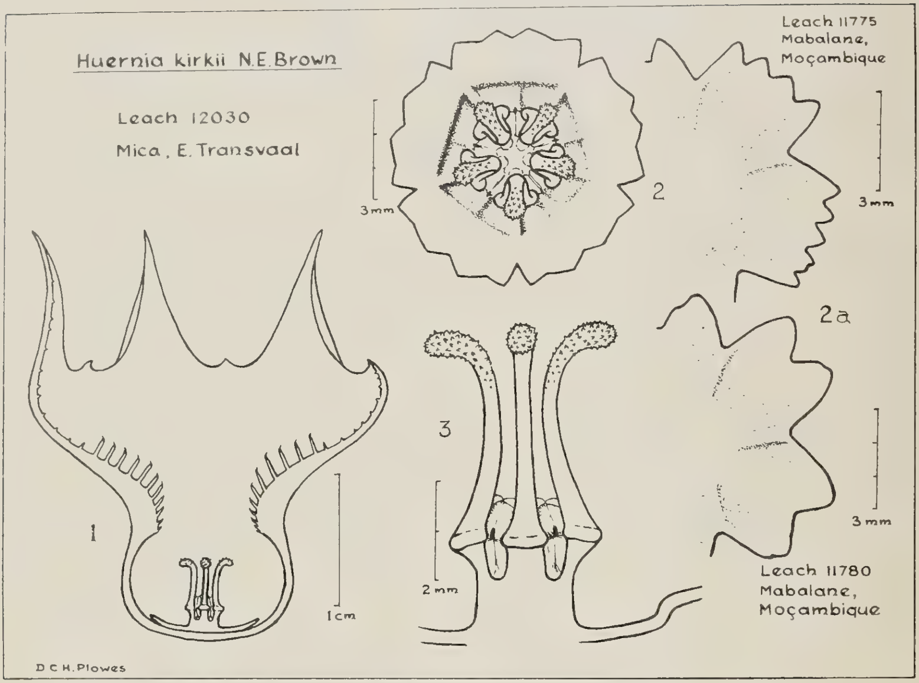
It has been found that dried material of the *Stapelieae* is often very difficult to interpret; many characters, obvious in the living plant, may be destroyed when the specimens are dried and pressed. In addition, individual aberrations may occur, e.g. a single plant of *H. longituba* collected near Lobatsi, shews inner corona lobes not clavate, all other characters remaining typically "*longituba*"; all other individuals from the same community and from elsewhere in Bechuanaland, now in cultivation at Nelspruit shew the distinctly clavate lobes typical of the species.

It is in an endeavour to cater for such difficulties and aberrations that as many characters as possible have been used in the key and some may well prove to be redundant in practice. The taxa generally have quite well defined distribution limits and should therefore, it is thought, present little diagnostic difficulty.

Huernia kirkii N. E. Brown in Th. Dyer, Fl. Cap. **4,** 1 : 920 (1909).—A. Berger, Stapelieen und Kleinien: 170 (1910).—White & Sloane, The Stapelieae **3** : 942 (1937) pro parte excl. fig. 1002, 1004, 1005 et t.XXIX.—Jacobsen, Handbook Succ. Pl. **2** : 623 (1960), pro parte excl. fig. 825.—Type: S. Africa, Transvaal, Komatipoort, 1902, *J. W. C. Kirk* s.n. (K holotype).

H. bicampanulata Verdoorn in Fl. Pl. S. Afr. **12** : t.449 (1932).—White & Sloane, tom. cit.: 941 (1937).—Luckhoff, Stapelieae of S. Afr.: 219 (1952). —Jacobson, tom. cit.: 618 (1960).—Type: S. Africa, Transvaal, Pietersburg Distr., *G. van Son* s.n. in Nat. Herb. 10136 (PRE, holotype).

S. Africa. Transvaal, Barberton Distr.: Komatipoort, 1902, *J. W. C. Kirk* s.n. (K); Hyslops Creek, fl. 6. v. 1935, *G. W. Reynolds* 1293 (PRE). Pietersburg Distr.: Farm Naauwpoort, ± 30 miles S of Pietersburg, fl. Dec. 1927, *G. van Son* s.n. in Herb. Transv. Mus. 28055 (PRE), cult. PRE, fl. March 1930 (PRE); ibid. fl. Jan. 1931, *Bremekamp & Schweickerdt* s.n. (PRE), fl. March 1932, cult Transv. Mus. 30616 (PRE), fl. Jan. 1932, cult. PRE 11302 (PRE); ibid.,



cult PRE, *G. van Son* s.n. in Nat. Herb. 10136 (PRE), fl. 5. iii. 1933, cult. Transv. Mus. 31813 (PRE). Piet Retief Distr.: Pongola, fl. May 1936, *J. F. de Wet* s.n. (PRE). Nelspruit Distr.: Kruger Nat. Park, near Malelane, fl. 12. v. 1950, *L. E. Codd* 6095 (PRE; SRGH); Kr. Nat. Park, near Sabie, fl. 20. iii. 1953, *H. P. v. d. Schijff* 2420 (PRE). Pilgrimsrest Distr., near Strydom Tunnel, fl. 20. iv. 1960, *Schlieben & Strey* 8407 (PRE; SRGH). Lydenburg Distr.: cult. *N. S. Pillans*, fl. Apr. 1934, *C. W. Foster* in Herb. Bolus. 27699 (BOL). Tzaneen Distr.: Mica, *Acacia* savanna, fl. May 1962, *D. S. Hardy* 922 (PRE); ibid., cult. NBG, fl. 10. iv. 1962, *J. W. S. Braine* in Herb. Compt. 60385 (NBG); ibid., cult. Nelspr. fl. Jan. 1965, *L. C. Leach* 12017 & 12030 (K; PRE; SRGH).

MOZAMBIQUE. Sul do Save: Mabalane, cult. PRE & Nelspr., fl. 25. iii. 1964 & Jan. 1965, *Leach & Bayliss* 11775 (BM; COI; K; PRE; SRGH); ibid., cult. NBG & Nelspr., fl. Feb. 1964 & Jan. 1965, *Leach & Bayliss* 11780 (BOL; G; LISC; NBG; PRE; SRGH); Limpopo Riv., near Pafuri, fl. 11. vii. 1964, cult. Nelspr., fl. Jan. 1965, *L. C. Leach, H. H. & D. C. Mockford* 12303 (CAH; LISC; K; PRE; SRGH).

The distribution of *H. kirkii* seems to be centred mainly on the lower Limpopo Riv. and its tributaries, in the E. Transvaal lowveld and the adjacent areas of Moçambique; the main concentration is, apparently, between Mabalane and Pafuri in Moçambique; literally masses of plants are to be found to the SE of Pafuri in association with numerous succulent and xerophytic species.

The species is rather rare in the region of the type locality (as commented on by Kirk) but more plentiful further to the N in the E. Transvaal; the locality for *L. E. Codd* 6095 seems to be the nearest of recent gatherings to that of the type, being only some 30 miles W of Komatipoort.

Considerable variations in the shape of the corolla may be found within a single community, e.g., *Leach & Bayliss* 11775 from Mabalane has a short, markedly pentagonal, parallel sided tube with a ± truncate base and an abruptly spreading limb with a narrow portion of the limb and lobes erect, while 11780 from the same locality has the "subglobose campanulate, constricted at the mouth" tube of the type, combined with a broad spreading limb and suberect lobes.

The lower part of the tube is usually unicoloured, shining dark purple although this may sometimes shew rather obscure transverse streaks of paler or whitish colour in individual specimens. The stems may be either 4 or 5-angled, both frequently occurring on the same plant.

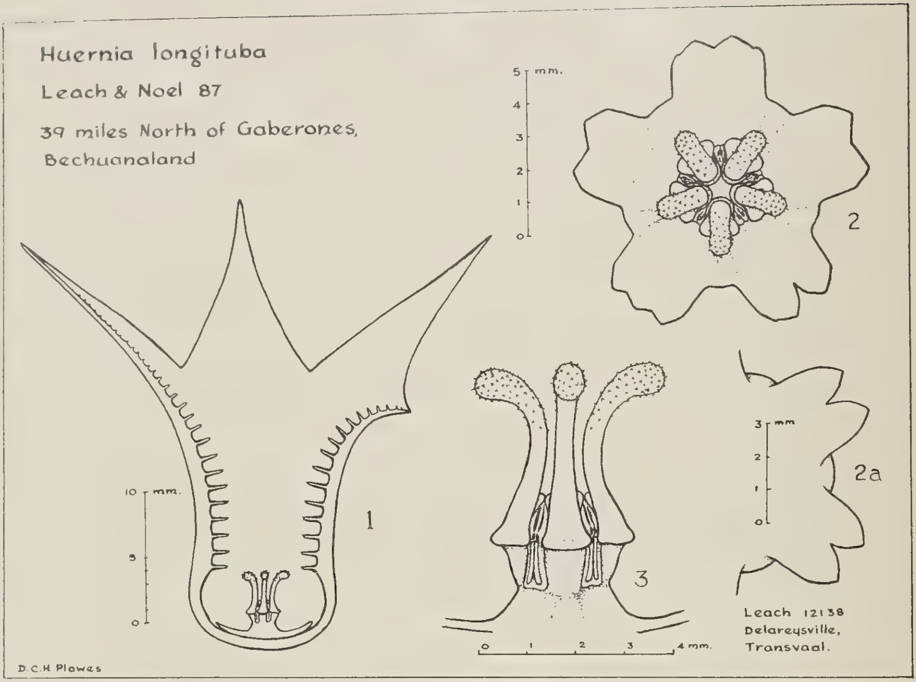
The plant figured in Fl. Pl. S. Afr. **12** : t. 442 (1932) was cultivated at Pretoria and is No. 10140 in the Nat. Herb., *J. J. van Nouhuys* s.n. "on shales near Barberton". This specimen appears to agree most closely with *H. hislopii* subsp. *robusta*; it is therefore thought likely that some confusion of plants in cultivation may have occurred as this taxon is not known to occur in the Transvaal.

Another specimen, *J. A. van Zyl* s.n. (PRE) also agrees very closely with the above; this, however, was collected from the Horticultural Research Station's rockeries at Nelspruit where succulent plants from many regions have been cultivated for a number of years.

The figures in both White & Sloane (*loc. cit.*) and Jacobsen (*loc. cit.*) appear to represent *H. hislopii* rather than *H. kirkii* while the notes regarding distribution and typical characteristics in both works seem to refer to a mixture of these taxa.

The *H. bicampanulata* of Bremek. & Oberm. in Ann. Transv. Mus. **16** : 429 (1935) is in fact *H. longituba* N. E. Brown.

Huernia longituba N. E. Brown in Th. Dyer, F1. Cap. 4, 1: 912 (1909).—— A. Berger, Stapelieen und Kleinien: 171 (1910).——Phillips in F1. P1. S. Afr. 10: t.380 (1930).——White & Sloane, The Stapelieae, **3**: 939 (1937).——Luckhoff, Stapelieae of S. Afr.: 218 (1952).——Jacobsen, Handbook Succ. P1. **2**:



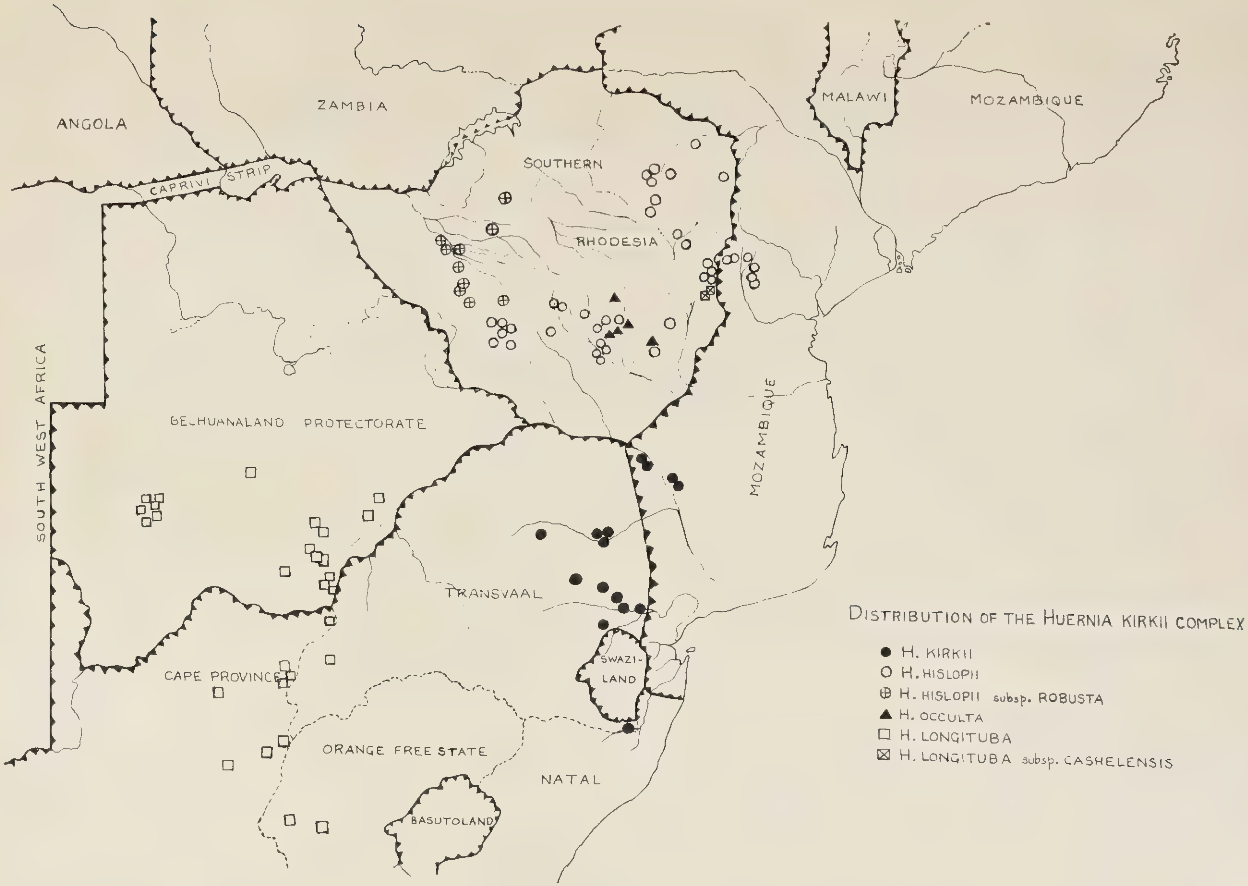
625 (1960).——Type: S. Africa, Cape Prov., near Douglas, *Pillans* 609 (BOL, isotype).

H. bicampanulata sensu Bremek. & Oberm. in Ann. Transv. Mus. **16:** 429 (1935).

Subsp. **longituba**

In the subsp. *longituba* the papillae are usually tipped with a short acute mucro but are without any long bristles, the tube is not at all basally ampliate and the stems may be either 4 or 5-angled.

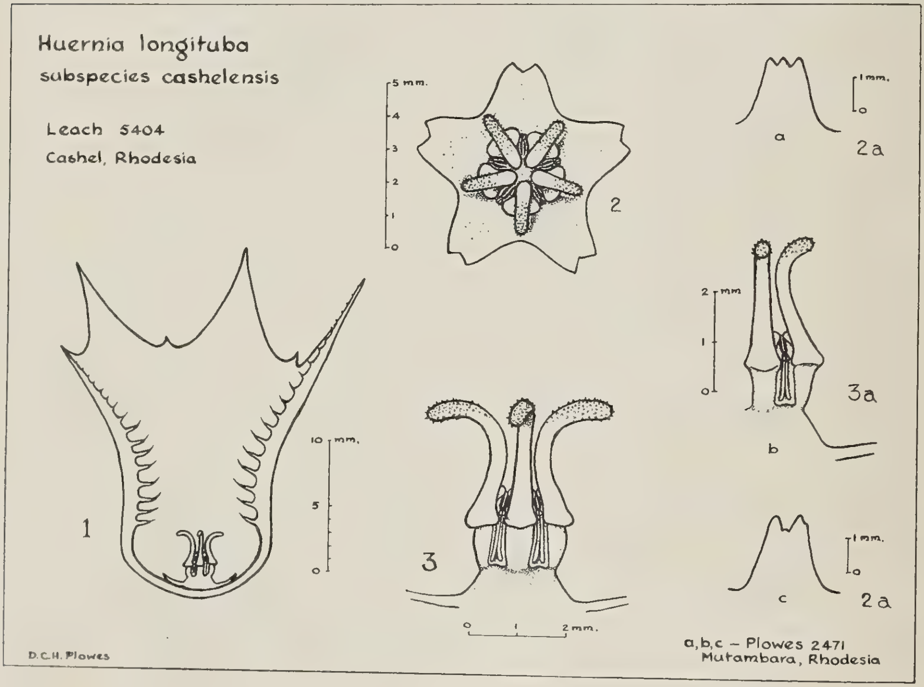
South Africa. Cape Prov., Barkly West Distr.: near Warrenton, fl. 27. iii. 1915, *I. B. Pole-Evans* s.n. (PRE); Holpan, *O. A. Leistner* 1528 (PRE). Herbert Distr.: near Douglas, fl. Apr. 1906, *Pillans* 609 (BOL). Kuruman Distr.: Kuruman, cult. NBG, fl. 13. iii. 1957, *H. Hall* in Herb. Compt. 66752 (NBG). Mafeking Distr.: Rooigrond, cult. Nelspr., fl. Jan. 1965, *R. D. Bayliss* in *Leach* 12139 (BOL; PRE). Vryburg Distr.: near Vryburg, fl. 5. iii. 1956, *B. Carp* in Herb. Compt. 44365 (NBG); ibid., cult. Karroo Gard., in Herb.



DISTRIBUTION OF THE HUERNIA KIRKII COMPLEX

Compt. 66752 (NBG); between Vryburg and Schweizer Reneke, fl. 21. iii. 1960, *F. Prins* s.n. (PRE). O.F.S., Fauresmith Distr.: Fauresmith, fl. March 1927, *C. A. Smith* 3902A (PRE); Luckhoff, fl. Apr. 1943, *Freund* 67 (BOL). Transvaal, Lichtenburg Distr.: Delareysville, cult. Nelspr., *R. D. Bayliss* in *Leach* 12138 (BOL; K; PRE; SRGH).

BECHUANALAND PROT., SW: near Lehututu, cult. Bulawayo Mus. 421, *M. Paterson* s.n. (K); near Tsane, cult. Bul. Mus. 23, 425 & 427, M. Paterson s.n. (CAH; SRGH); ibid., cult. NBG, fl. 16. i. 1957, in Herb. Compt. 44364 (NBG). SE; Kuke Pan, fl. March 1930, *G. van Son* in Herb. Transv. Mus. 28757 (PRE); near Molepolole, cult. PRE, fl. 6. i. 1955, *L. E. Codd* 8914 (PRE); ibid., cult. Nelspr., fl. Feb. 1965, *Leach, Bayliss & Lamont* 12488 (G; K; LISC; PRE); 32 m. W of Kanye, fl. 18. i. 1960, *Leach & Noel* 204 (PRE; SRGH); between Gaberones and Artesia, fl. 15. i. 1960, *Leach & Noel* 83 (CAH; SRGH); ibid., cult. Greendale, fl. 3. vi. 1960, *Leach & Noel* 232 (SRGH); near Lobatsi, cult. Greendale, fl. 22. ii. 1961, *Leach & Noel* 87 & 135 (SRGH); ibid., cult. Nelspr., fl. Feb. 1965, *Leach, Bayliss & Lamont*



12451 (BM; BOL; COI; G; K; LISC; PRE; SRGH), 12463 (BOL; PRE), 12473 (SRGH); near Mashupa, N of Kanye, cult. Nelspr., fl. Feb, 1965, *Leach, Bayliss & Lamont* 12468 (K), 12469 (BM; PRE; SRGH).

Subsp. **cashelensis** Leach & Plowes, subsp. nov.

A subspecie typica processis et papillis plerumque setis instructis, tubo saepe leviter ampliato, caulibus 5/6-angulatis differt.

TYPE: *L. C. Leach* 5404 (K; PRE, holotype; SRGH).

The subspecies *cashelensis* differs from the type in having the processes and papillae usually tipped with a stiff bristle, a tube which is frequently slightly basally ampliate and 5/6-angled stems. In length of tube, the extent to which the inner corona lobes are recurved, tuberculate, clavate or obtuse and in the length of the setae (which are frequently as long as the papillae), this subspecies is very variable.

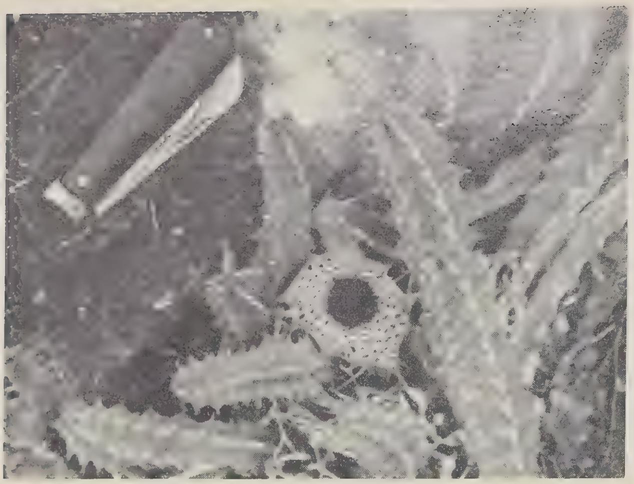
S. RHODESIA. Melsetter Distr.: ± 6 miles W of Cashel, on bare stony slope in sparse deciduous scrub woodland, alt. c. 2750′, cult. Greendale, fl. March 1958, cult. Pretoria, fl. 28. i. 1959, *L. C. Leach* 5404 (K; PRE; SRGH); Mutambara, fl. 15. ii. 1965, *D. C. H. Plowes* 2471 (SRGH).

H. longituba is by far the least confused of the taxa under consideration, nevertheless it has occasionally been mistakenly identified with one or other of the related species.

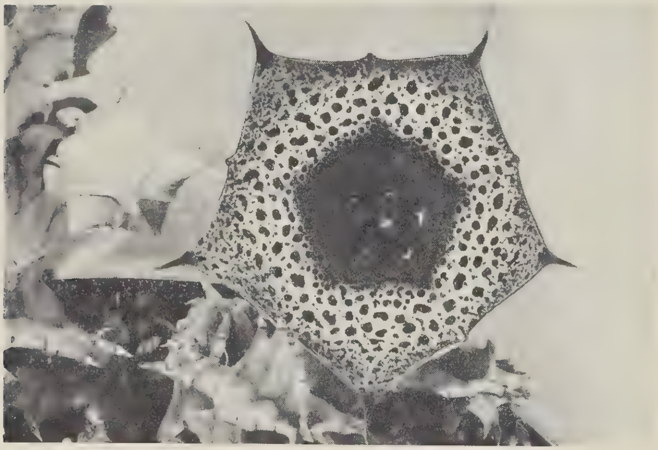
There seems little of consequence to add to the original description by N. E. Brown beyond the fact that the normally clavate inner corona lobes are minutely tuberculate.

There is considerable variation in the length of the tube and the extent to which the limb and lobes may be suberectly or widely spreading; the flowers, sometimes, when the lobes are suberect, presenting an almost equally 10-lobed aspect (despite the small size of the intermediate lobes), this being particularly evident in the subspecies *cashelensis*.

The distribution of the subsp. *longituba* extends from Douglas in the Northern Cape and Fauresmith in the O.F.S. more or less northwards into Bechuanaland Protectorate and the western Transvaal as far north as Mahalapye in Bechuanaland. There is, to date, no record of this taxon from Rhodesia; the disjunct distribution of the subsp. *cashelensis* does, however, occur in the Eastern Districts of that country where it seems to be confined to a relatively small area in the vicinity of Cashel. Plants are generally rather smaller than those of the typical subspecies and the smaller flowers are more orange coloured in appearance (due to the orange-red spots) and are more variable than those of the subsp. *longituba*.

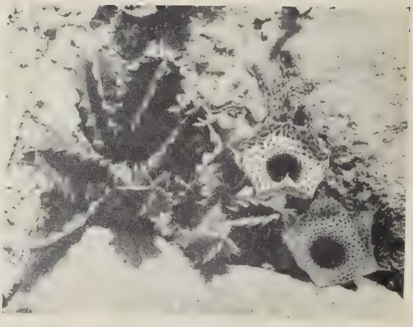


L. E. Codd 6095, *H. kirkii*, Malelane, E. Transvaal; near type locality.
Photo: Dr L. E. Codd.



Leach and Bayliss 11775, *H. kirkii* from Mabalane, Moçambique; shewing markedly angular tube.
Photo: Botanical Research Institute Pretoria.

Variation in corollas, Mabalane community.
Photo: L. C. Leach.



Variation in corolla markings, Pafuri community. *Photo: L. C. Leach.*

Plate 1.

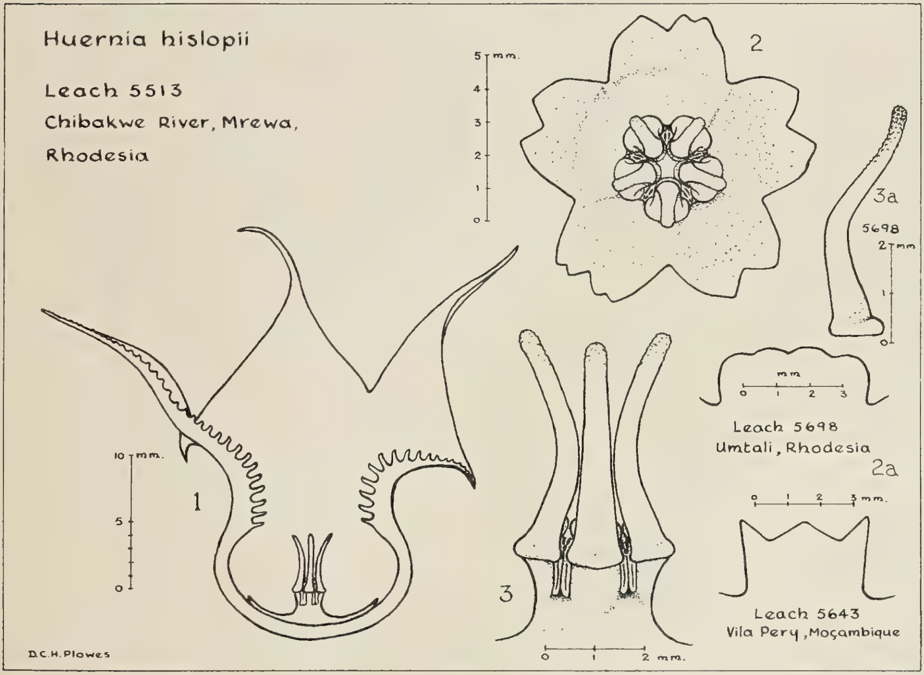
Huernia hislopii Turrill in Kew Bull. **1922:** 30 (1922).——White & Sloane, The Stapelieae **3:** 944 (1937) pro parte excl. fig. 1007.——Luckhoff, Stapelieae of S. Afr.: 224 (1952).——Jacobsen, Handbook Succ. Pl. **2:** 622 (1960) pro parte quoad fig. 822.——Type: S. Rhodesia, cult in Hort. Bot. Reg. Kew., No. A 191, *A. Hislop* s.n. (K, holotype).

H. kirkii sensu White & Sloane, tom. cit.: 942 (1937) pro parte excl. descr. ——Jacobsen, tom. cit.: 623 (1960) pro parte quoad fig. 825.

H. scabra sensu Markgraf apud Suesseng. & Merxm. in Trans. Rhod. Sci. Ass. **43:** 128 (1951).

Subsp. **hislopii**

The subsp. *hislopii* has the tube rather sharply constricted at the throat with the ampliate basal portion longer than the throat, conspicuously globose-inflated and distinctly concentrically lined with colour within; the corolla lobes are normally much longer than broad and are markedly attenuate while the stems are 5-angled.



S. Rhodesia. Bikita Distr.: 52 m. E of Fort Victoria, cult. NBG, fl. 1. iii. 1953, *E. Schelpe* in Herb. Compt. 44376 (NBG). Chibi Distr.: near Chibi Village, cult. Greendale, fl. Dec. 1957, *Leach* 5474 (SRGH); near Rhino Hotel, Lundi Riv., fl. 4. v. 1961, *R. B. Drummond & R. R-Smith* 7692 (SRGH); ibid., fl. 5. xii. 1961, *Leach* 11297 (K; PRE; SRGH); ibid., fl. 6. v. 1963, *Leach* 11646 (BM); Turgwi/Turkwana Riv. confluence, fl. 7. xii. 1961, *Leach* 11333 (SRGH). Goromanzi Distr.: Arcturus, Ewanrigg, fl. 22. i. 1932, *H. B. Christian* 5426 (PRE; SRGH); ibid., fl. 5. vii. 1941, *I. C. Verdoorn* s.n. (PRE); Domboshawa, cult. Greendale, fl. 16. ii. 1958, *Leach* 5734 (SRGH); Gwanda Distr.: near Gwanda, cult. Bul. Mus. 33, fl. 27. x. 1956, *M. Paterson* s.n. (K). Marandellas Distr.: Digglefold, fl. 14. i. 1961, *H. Corby* 954 (SRGH); Matobo Distr.: Farm Boomerang, cult. Bul. Mus. 17, fl. 18. xii. 1956 (K); Absent Farm, cult. Bul. Mus. 29, *M. Paterson* s.n. (BOL); Old Gwanda Road, cult. Bul. Mus. 120 & 332, *M. Paterson* s.n. (CAH); ibid., fl. 30. xi. 1963, *Leach & Bullock* 12001 (SRGH); ibid., fl. March 1965, *Plowes & Bullock* 2489 (BOL; COI; K; SRGH); Matopos, "cult. Sherwood", fl. Dec. 1906, in Herb. Bolus. 10755 (BOL); E. Matopos, cult. NBG, fl. 22. ii. 1957, *R. Smithers* in Herb. Compt. 44375 (NBG). Mrewa Distr.: Chibakwe Riv., cult. Greendale, fl. Apr. 1957, *Leach* 5513 (SRGH); Shamba Riv. fl. 25. iv. 1960, *Leach* 9875 (PRE; SRGH). Ndanga Distr.: Zaka, fl. June 1950, *H. Hall* 106 (NBG); Nuanetsi Distr.: near Rhino Hotel, Lundi Riv., fl. 6. v. 1963 *Leach* 11642 (BM; BOL; G; K; PRE; SRGH). Inyanga Distr.: Inyanga North Res., fl. Feb. 1957, *Leach* 5646 (CAH; PRE; SRGH); without precise loc., cult. Bul. Mus. 49, fl. 16. xi. 1956, *M. Paterson* s.n. (CAH). Rusape Distr.: Rusapi, cult. NBG, fl. Apr. 1918, *A. Hislop* in Herb. Bolus. 10735 (BOL); without precise loc. (?Rusapi), cult. Hort. Bot. Reg. Kew. No. A191, 1920, *A. Hislop* s.n. (K); Salisbury Distr.: "on a kopje near Salisbury", fl. Feb. 1906, *J. Ffolliott-Darling* in Herb. Bolus. 10767 (BOL); Salisbury, cult. NBG, fl. 17. iv. 1941, *G. E. Clarkson* in Herb. Compt. 44380 (NBG). Shabani Distr.: Lundi Res., cult. PRE, fl. 10. xi. 1956, *D. Plowes* 1890 & 1895 (PRE). Umtali Distr.: Vumba, Norseland, fl. March 1949, *H. Wild* 2805 (K; SRGH); Zimunya Res., fl. Dec. 1952, *Watermeyer* s.n. (SRGH); 15 m. S of Umtali, cult. Greendale, fl. 9. xii. 1958, *Leach* 5698 (SRGH); Burma Valley, fl. 22. ii. 1962, *N. C. Chase* 7647 (SRGH). Victoria Distr.: Mushandike Riv., fl. March 1958, *Leach* 5747 (SRGH); Lake Kyle, fl. 5. xii. 1960, *Leach* 10552 (PRE; SRGH); Bangala Falls, cult., fl. 28. iii. 1965, *B. Baker* in *Leach* 12760 (PRE). "Kalahari Region" fl. June 1919, *S. Tapscott* in Herb. Bolus. 10735A (BOL).

Mozambique. Manica e Sofala: Revue Riv., Vila de Manica, fl. 10. iii. 1948, *Garcia* in *Mendonça* 563 (LISC); Bandula, cult. PRE, fl. 18. ix. 1956, *Leach* 5644 (PRE; SRGH); near Mt. Zembe, cult. Greendale, fl. Feb. 1957 &

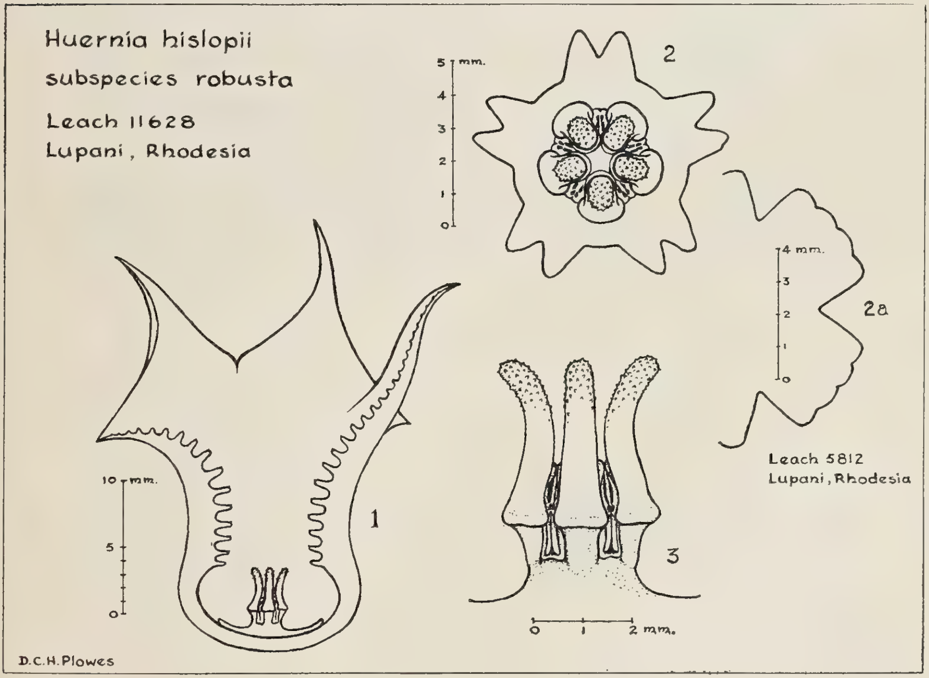
Feb. 1958, *Leach* 5643 (PRE; SRGH); near Vila Pery, cult, PRE and Greendale, fl. Sept. 1956 & Feb. 1958, *Leach* 5642 (K; PRE, SRGH); near Vila de Manica, cult. Greendale, fl. Feb. 1957, *Leach* 5645 (CAH; LISC; SRGH); ibid., fl. 23. v. 1960, *Leach* 9954 (SRGH).

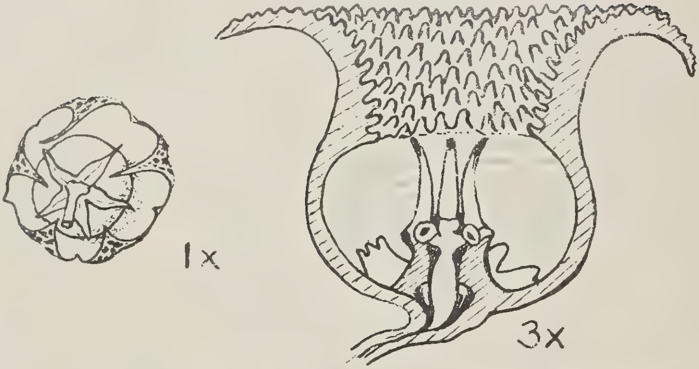
Subsp. **robusta** Leach & Plowes, subsp. nov.

A subspecie typica basi tubi tantum leviter ampliata intus paulo obscurolineata, fauce plerumque longiore quam parte ampliata, lobis corollae plus minusve deltatis plerumque tantum breviter attenuatis, caulibus 5/7-angulatis differt.

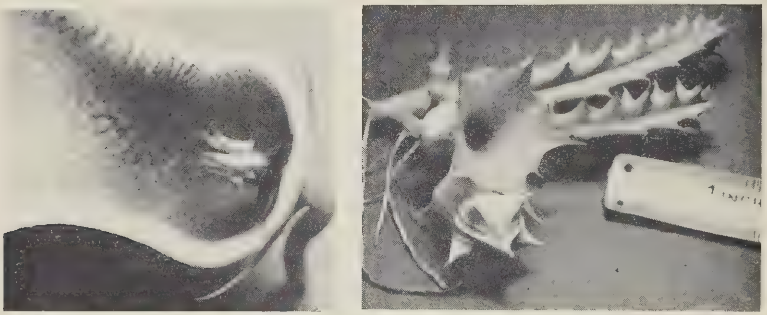
TYPE: *L. C. Leach* 11628 (BM; CAH; G; K; LISC; PRE; SRGH, holotype).

The tube of the subsp. *robusta* is only slightly basally ampliate, very obscurely concentrically lined within and has the throat at least as long as the ampliate portion; the corolla lobes are about as long as or very little longer than broad and are comparatively shortly attenuate; the stems are 5/7-angled.

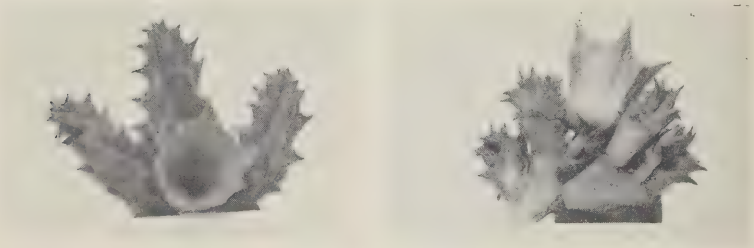




A copy of the drawing by Miss D. K. Hughes, from the type sheet of *H. Hislopii*.



H. hislopii subsp. *robusta*. *Plowes* 1699 Plant from Nyamandhlovu, S. Rhodesia.
Photo: D. C. H. Plowes.



H. longituba subsp. *cashelensis*. Clone of the type plant. *Leach* 5404.
Photo: L. C. Leach.

Plate 2.

S. Rhodesia. Gokwe Distr.: Charama Road, cult. Gokwe, fl. Oct. 1963, *M. G. Bingham* 874 (SRGH). Lupani Distr.: Mabikwa, fl. 1. iv. 1963, *Leach* 11628 (SRGH), idem, cult. Nelspr., fl. Jan. 1965 (BM; CAH; G; K; LISC; PRE; SRGH); ibid., cult. Greendale, fl. 9. iv. 1960 *Leach* 9835 (SRGH); ibid., cult. Nelspr., fl. Jan. 1965, *Leach* 12112, 3 & 4 (BOL; K; PRE; SRGH). Nkai Distr.: Shangani Res., Bulawayo Mus. 110 (BOL). Nyamandhlovu Distr.: Bongolo Farm, fl. March 1954, *D. C. Plowes* 1699 (PRE; SRGH); Galeta's Kraal, fl. Jan. 1956, *D. C. Plowes* 1910 (PRE); ibid., cult. Bul. Mus. 44, *M. Paterson* s.n. (BM); Sawmills, cult. Bul. Mus. 316, 317 & 319, *M. Paterson* s.n. (G; K; LISC; PRE; SRGH); near Bulawayo, cult. PRE & Greendale, in *Leach* 9971 (SRGH).

Huernia hislopii is essentially a Rhodesian plant, with a distribution not known to extend beyond that country's borders, except for a small extension into a limited area of Moçambique adjacent to the Umtali District.

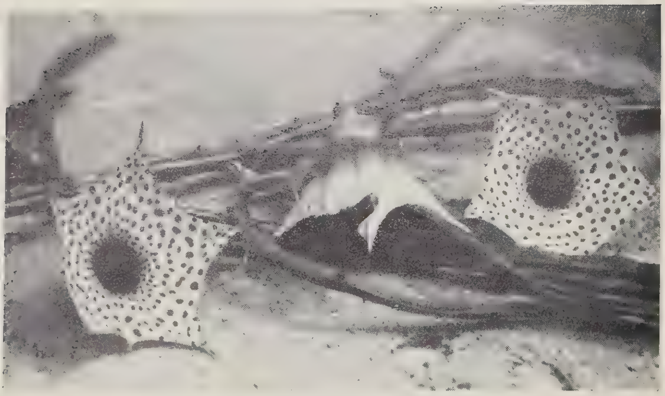
The known habitats of this subspecies are almost entirely confined to the granite kopje areas of the country; plants are probably most plentiful in the Victoria District.

The type plant was sent to Kew, without locality, by Mr. A. Hislop of St. Faith's Mission, Rusapi; it seems likely that this would have been collected in the vicinity of Rusapi, in which area, plants typical of the subspecies are known to occur. This supposition appears to be confirmed by the locality given for the Hislop material in the Bolus Herbarium.

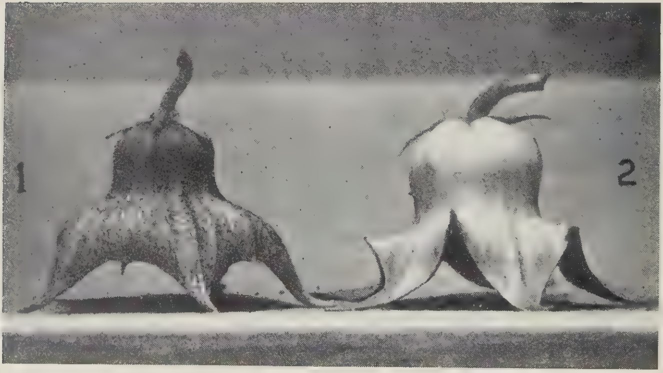
There seems nothing to add to the original description of this taxon which would in any way clarify the position beyond mentioning, that in nature, flowers are produced successively from a point and are never solitary as was the case with the type plant cultivated at Kew.

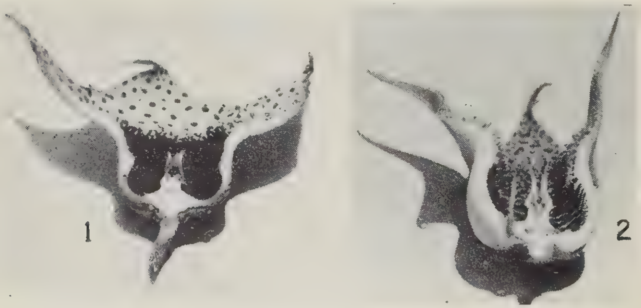
The distribution of the subsp. *robusta* extends more or less northwards from Bulawayo, as far as Lupane to the NW and Gokwe to the NE, an area where the subsp. *hislopii* is not known to occur; plants are found mainly on the sandy or gravelly soils of the thorn bush and *Mopane* veld. A slight possibility exists that this taxon may eventually be found to have a disjunct extension in the Eastern Transvaal (see note relating to cultivated specimens *J. J. van Nouhuys* and *J. A. van Zyl*, under *H. kirkii*).

Plants of the subsp. *robusta* are generally larger and more robust than those of the typical subspecies and are much more variable, some specimens superficially appearing to resemble *H. longituba* more closely than *H. hislopii*. However, it is considered that the form of the inner corona and particularly of the papillae definitely places this taxon in closer relationship with the latter species than with any other member of the complex; occasionally specimens, especially when dried, do exhibit very slightly clavate inner corona lobes and for this reason it has been included in both sections of the key.



H. occulta shewing slender stems.





A comparison of the corallas of **1.** *H. occulta* & **2.** *H. hislopii.*

Plate 3.

There is considerable variation of both size and shape of the outer corona lobes; this, however, is a factor common to most species of the genus and one which renders the outer corona relatively useless for diagnostic purposes; some of the most distinct variations are shewn in the sketches of *H. hislopii* and *H. kirkii.*

The plant figured in Fl. Pl. S. Afr. **19:** t. 758 (1939) is not *H. hislopii* but is a new species (*H. occulta*), now described elsewhere in this paper.

The notes in White & Sloane (*loc. cit.*) concerning typical characteristics refer apparently to a mixture of *H. hislopii* and *H. occulta.*

Huernia occulta Leach & Plowes, sp. nov.

H. hislopii sensu White & Sloane, The Stapelieae **3:** 945 (1937) pro parte quoad fig. 1007.——Phillips in Fl. Pl. S. Afr., **19:** t. 758 (1939).

H. hislopii Turrill affinis sed caulibus multo tenuioribus longioribus repentibus, limbo corollae late pateriformi, papillis minoribus et minus confertis, tubo breviore, extus plus minusve cylindrico, base loborum coronae interioris obtuso plerumque sine gibba transversa multo propiore coronam exteriorem differt.

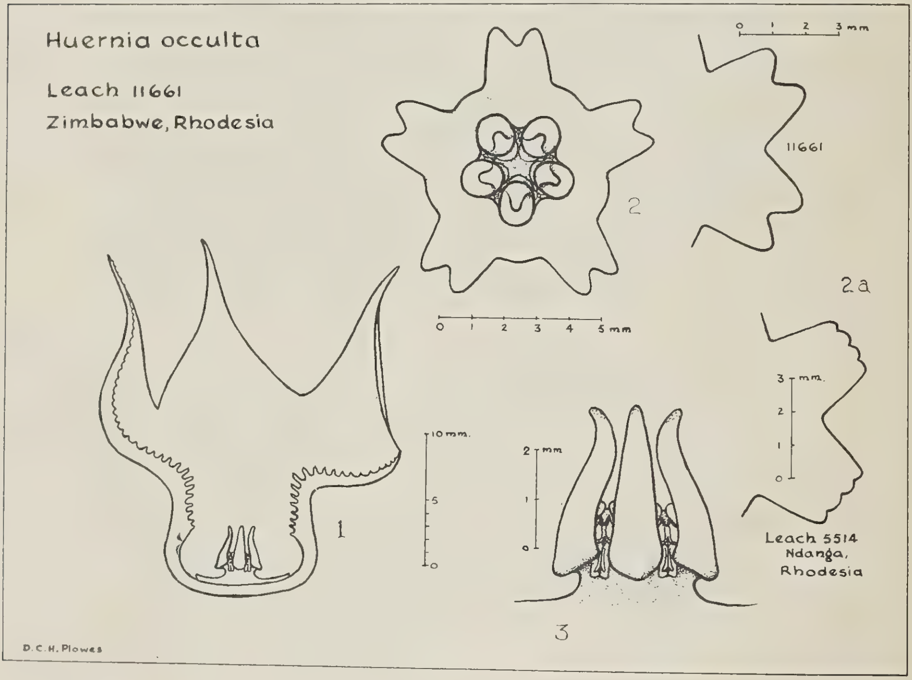
Planta repens succulenta perennis, caulibus tenuibus. *Caules* glabri virides valde sulcati, angulis 5 obtusis, usque 32 cm. longi, 3—9 mm. diam., dentibus acutis patentibus 1—3 mm. altis, 1—3 cm. distantibus. *Bracteae* attenuatae 2—4 mm. longae, 0·5—0·75 mm. latae. *Pedicelli* teretes glabri 12—24 mm. longi, c. 1·5 mm. diam., *Sepala* anguste ovata acuminata glabra 6—8 mm. longa, 1·5 mm. lata. *Flores* pallide lutei maculis fulvo-sanguineis punctati, deinceps aperientes versus basem caulium juvenium parce producti. *Corolla* bicampanulata, extus versus basem plerumque leviter scabra deinde paene glabra; intus tubi pars inferior glabra fulgida atropurpurea, fauce et circum os papillis conicis dense induta, limbo et lobis papillis brevioribus parce indutis; tubus ad basem aliquantum truncatus, extra plus minusve cylindricus, ore interdum perleviter constrictus, c. 7·5 mm. longus, 10 mm. diam.; limbus pateriformis, c. 2·25 cm. diam.; lobi deltati acuminati, c. 12 mm. lati, 13 mm. longi, suberecti vel patuli, apicibus plerumque aliquantum recurvis, margine minute tuberculato; lobi intermidii parvi acuti. *Corona* exterior c. 8 mm. diam. basi tubi adpressa, fusco-purpurea dense minutissime tuberculata, lobis 5, subquadratis obtusis valde emarginatis, *Coronae interioris* lobi glabri, c. 3·5 mm. longi, subteretes crassi suberecti conniventes, superne aliquantum abrupte attenuati apicibus leviter divergentibus (raro recurvis) minutissime obtuso-tuberculatis vel minutissime rugulosis, haud clavatis, basibus paene ad coronam exteriorem attingentibus obtusis plerumque sine gibba transversa.

TYPE: *L. C. Leach* 11661 (K; PRE; SRGH, holotype).

S. RHODESIA. Victoria Distr.: hills between Umvuma and Fort Victoria, cult. PRE, *G. van Son* in Nat. Herb. 20156 (PRE); ibid., cult. Transv. Mus., fl. Nov. 1932, Jan. & Feb. 1934, *G. van Son* in Herb. Transv. Mus. 31057A, B & C (PRE); "Fort Victoria area", cult. PRE, fl. 10. xi. 1953, *G. C. Reyneke* 5 (PRE; SRGH); near Zimbabwe, cult. Greendale, fl. 27. iii. 1958, *L. C. Leach* 5746 (BM; SRGH); ibid., on granite slope, amongst perennial grasses with various succulent species, *L. C. Leach* 11661 (K; PRE; SRGH); ibid., cult. Bul. Mus. 504, *M. Paterson* s.n. (CAH). Ndanga Distr.: near Ndanga, cult. Greendale, fl. 20. iv. 1958, *L. C. Leach* 5514 (SRGH).

This species is also reported from the Matopos Hills, Matobo District, by Mrs. B. Ball (M. Paterson) but unfortunately no material has been preserved.

Huernia occulta is a very distinctive species, most closely related to *H. hislopii*; it is very easily distinguished from that species by its long very slender creeping stems. The handsome flowers with their very much smaller "*Huernia* teeth" and rather shallow more or less cylindric tube which is shining dark purple inside also contrast sharply with those of *H. hislopii* which have long reflexed intermediate lobes and an inflated concentrically lined tube. There



are also considerable differences in the coronas and in the papillation of the two species.

The name *occulta* was chosen primarily because of its habit of growing and producing its flowers in very heavy shade, the plants remaining almost completely hidden at all stages of growth and secondly because its identity had for so long been concealed by its confusion with *H. hislopii.*

Plant a succulent perennial herb with slender branching stems creeping among grasses, rooting where touching the soil. *Stems* glabrous, green, deeply sulcate with 5 rounded angles, up to 32 cm. long, 3—9 mm. diam. with acute spreading teeth 1—3 mm. high, 1—3 cm. apart along the angles. *Bracts* attenuate 2—4 mm. long, 0·5—0·75 mm. wide. *Pedicels* terete, 12—24 mm. long, c. 1·5 mm. diam., glabrous. *Sepals* very narrowly ovate acuminate 6—8 mm. long, 1·5 mm. wide, obtuse beneath, glabrous. *Flowers* cream with many tawny red spots on the limb and lobes with the base of the tube shining blackish purple, produced sparingly successively from towards the base of the young stems. *Corolla* bicampanulate, generally slightly scabrid outside towards the base, becoming almost completely glabrous on the lobes; the lower portion of the inside of the tube glabrous, with the throat and around the mouth densely covered with more or less conical papillae, the remainder of the limb and lobes less densely covered with very much shorter papillae (the two kinds intermingled around the mouth) and the margins minutely tuberculate; tube more or less cylindric outside, occasionally very slightly constricted towards the mouth, generally somewhat truncate at the base, c. 7·5 mm. long, 10 mm. diam.; the shallowly saucer shaped limb spreads rather abruptly from the mouth of the tube and is about 2·25 cm. diam. to the base of the lobes; lobes deltate acuminate, suberect or spreading with the apices usually somewhat recurved, the outer surface 5-nerved, the median nerve prominently ridged, c. 12 mm. broad at the base, c. 13 mm. long; intermediate lobes small, acute, spreading (erect in bud) 1—1·5 mm. long. *Outer corona* densely microscopically tuberculate, closely adpressed to the base of the tube, c. 8 mm. diam., with 5 subquadrate deeply emarginate obtuse lobes. *Inner corona*: lobes c. 3·5 mm. long, subterete, stout, suberect, connivent, tapering rather sharply in the apical third to the slightly divergent (rarely recurved), minutely obtusely tuberculate or minutely rugulose apices, which are not at all clavate; the inner corona is mounted low down on the staminal column so that the obtuse base of the lobes is very close to, sometimes almost touching, the surface of the outer corona.

ACKNOWLEDGEMENTS

The authors wish to express their sincere thanks to:

Mr. & Mrs. E. J. Bullock for living plants and material from the Bulawayo and Matobo Districts of S. Rhodesia.

The Directors of the Bolus Herbarium, University of Cape Town, the Centro de Botânica da Junta de Investigações do Ultramar, Lisboa, the Compton Herbarium, Kirstenbosch, the Herbarium of the Botanic Gardens, Stellenbosch and the Herbarium of the University College of Rhodesia & Nyasaland, for the loan of material.

Dr. L. E. Codd, Chief, Botanical Research Institute, Pretoria, and his staff, for the facilities of the Herbarium, for many helpful discussions, for photographs and material as well as many living plants.

The Director, Royal Botanic Gardens, Kew, for sending material on loan to Pretoria and Salisbury and for permission to publish a copy of the figure of *H. hislopii*, taken from the type sheet.

Mr. D. S. Hardy for numerous living specimens from his garden at Pretoria North.

Mr. & Mrs. G. Lamont of Lobatsi and Mr. & Mrs. H. H. Mockford of Pafuri for their hospitality and for much assistance when the *Stapelieae* of SE Bechuanaland Protectorate and of the Pafuri area were investigated.

Dr. H. Wild and the staff of the Government Herbarium, Salisbury, for the facilities of the Herbarium and a great deal of help in many directions.

A NEW POISONOUS AGARIC FROM THE CAPE PENINSULA

EDITH L. STEPHENS

(*Hon. Reader in Fungi, Bolus Herbarium, University of Cape Town*)

ABSTRACT

Clitocybe toxica. E. L. Stephens is a caespitose species growing in quantity in a wood of mixed conifers on Wynberg Hill and is the first record for South Africa of a species in the sub-section *Difformes* established by Fries. Its toxicity to test animals is such as to make it advisable to warn humans against it.

Clitocybe toxica. E. L. Stephens. sp. nov. caespitosa, stipites tres usque ad tringinta, cum basi coniuncti, pileo carnoso, convexo, saepe cum umbone humili, vel, postremo, plano; margine inflexo vel reflexo, colore primo fulvo-brunneo (Buffy-Brown) deinde olivo-brunneo, postea cinnamo-brunneo, postremo atro-brunneo. Lamellis subcurrentibus, separatis fere uno millimetro, primo arcuatis vel lineis rectis, in dimidia parte posteriore latius se extendentibus; albus deinde colore fulvo subfusco, margine brunneo, postremo fusco. Stipes primo solidus, deinde cavus cylindricusque, plerumque ad basim curvatus et transvere compressus, striatus. Colore "light-buff", deinde "snuff-brown", postremo "clove-brown". (Colores sicut Ridgway: Color Standards.)

DISTRIBUTION AND DESCRIPTION

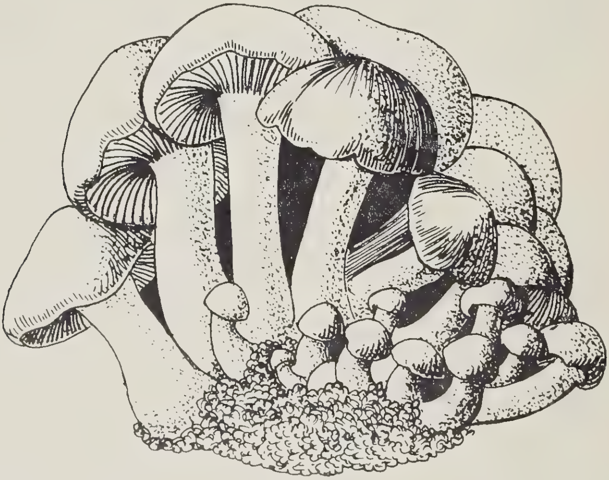
This is the third species of the large genus Clitocybe (which according to Singer, p. 185, contains 200 to 300 species) to be recorded for the Cape Peninsula. One of the other two, *C. olearia*, is also poisonous (Stephens & Kidd. p. 18). *C. toxica* is the first endemic species to be reported from South Africa.

The largest group of specimens found so far were pushing up the pine-needle carpet in a small wood of mixed conifers off Monterey Avenue, on the upper slopes of Wynberg Hill and close to the formation of granite boulders known as the "Hen and Chickens". There it was collected by Mr. Frank Chapman in August 1964 and on subsequent dates, and he has also found it in the Tokai Forest. Outside the Cape Peninsula, the only record is a small collection brought by Mr. H. Major from Elgin.

Although, like most of our Agarics, it is most abundant in the rainy season (on the Cape Peninsula from May to October) it can apparently appear at almost any time of the year, given sufficient moisture. Thus in November 1964, 100 clumps were found on the Monterey Avenue site, and in early May 1965, about 200 clumps, after intermittent April rains.

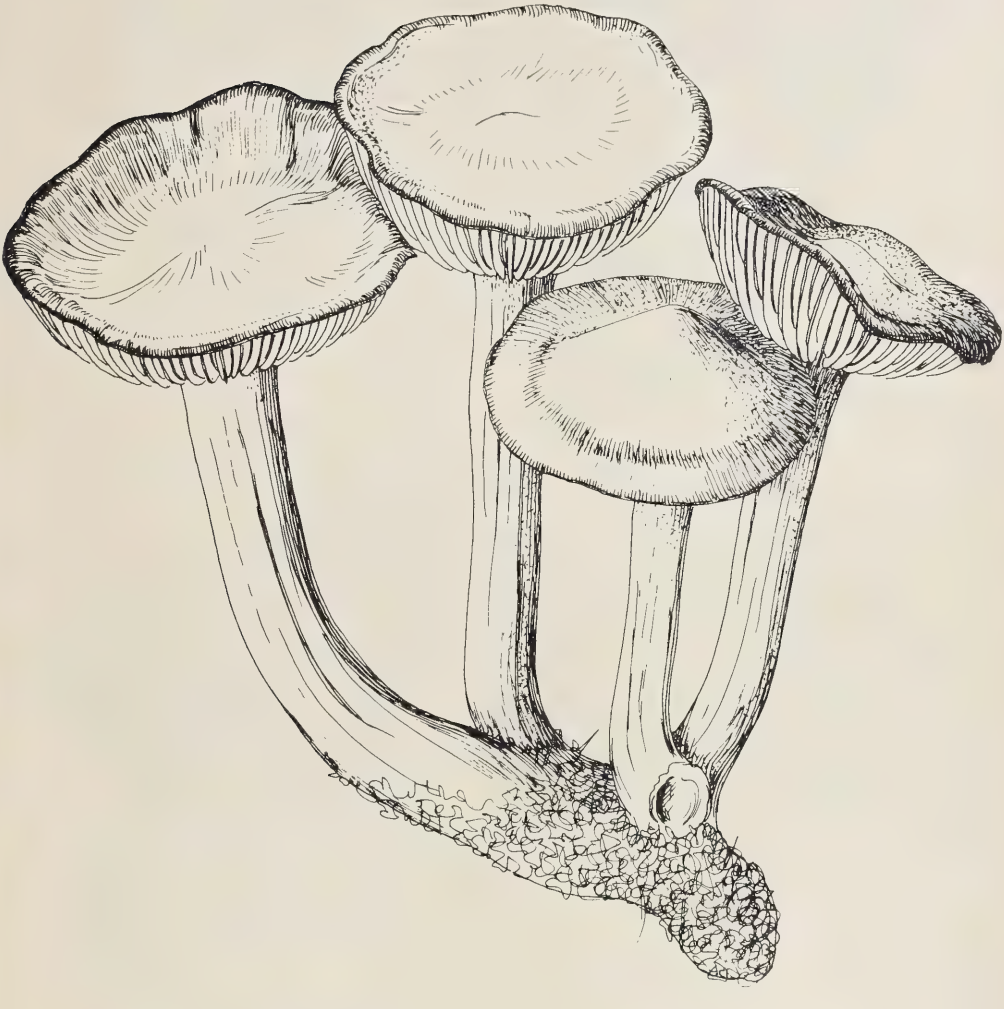
The specimens are rarely solitary, generally caespitose, in clumps of three to thirty basally-connected individuals (Fig. 1 and Plate 1). Most commonly, five or six mature in a clump. They are hygrophanous, having a water-soaked appearance when wet.

The *Cap* varies in diameter from about 1·5 cm. when young up to 9 cm. or more in the older members of the clump. Its shape is at first conical to convex, then expanding to broadly convex, often with a low umbo, or becoming flat (fig. 2). The margin is at first smooth and regular, either straight or incurved; when mature it often becomes wavy, and is either upcurved or downcurved. The general *colour* of the cap when young is buffy-brown, deepening when mature to olive-brown, then cinnamon-brown to mummy-brown, and finally in decay darkening to a blackish-brown (colours as in Ridgway). But other shades of yellow and brown such as chamois, brownish-olive and Saccardo's umber often mingle in the largest caps. The older caps are often edged by a narrow margin of dark brown, deepening to bistre and mummy-brown. A light dusting of white from the basidiospores of the taller caps is often seen on the lower ones in the clump.



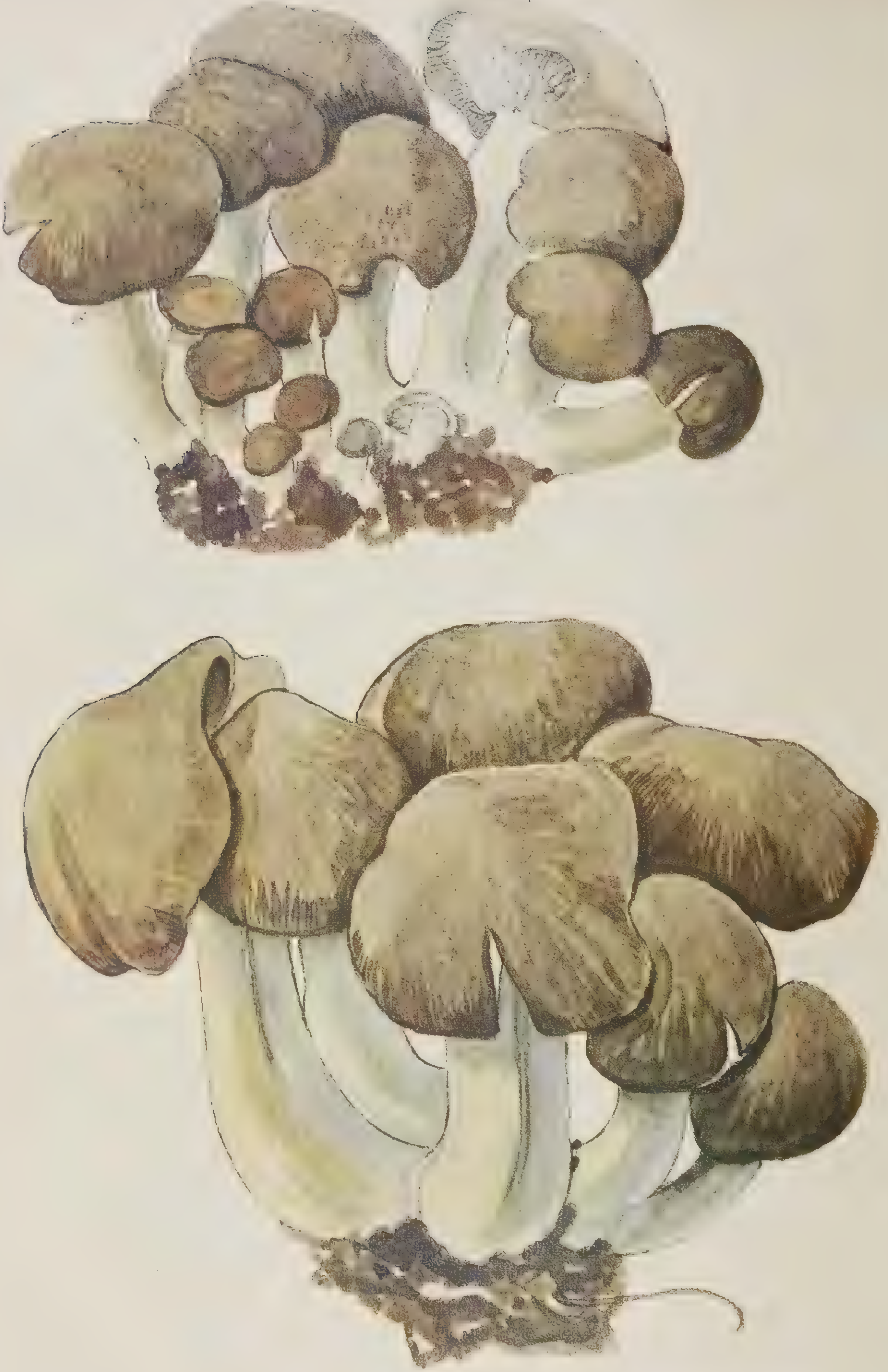
Mary Maytham Kidd

Fig. 1. A young clump of *C. toxica*. Life size.



Mary Maytham Kidd

Fig. 2. Part of a mature clump of *C. toxica*. Three-quarters life size.



Mary Maytham Kidd

Developing clumps of *Clitocybe Toxica*. Life size.

The *gills* are subdecurrent, are spaced in the mature cap about a millimetre apart, and are not easily separable. They are linear to arcuate when young, and at first narrow, but later broaden behind to about a centimetre in width; the front half continues to narrow to the margin of the cap. There are several lengths of gill, the shorter ones reaching to about halfway between margin and stem. These shorter gills are often wavy and minutely toothed, while the full-length ones are straight-edged with only occasional teeth. The colour of the gill is off-white when young, changing to light buff, and when ageing becoming tinged along the edge with light brown; finally in old age they are fuscous.

The mature *stem* (fig. 2.) is 5 to 15 cm. long, diameter 1 to 2 cm. Its texture is cartilaginous. At first cylindrical, it may remain so in the taller members of a clump, but generally the lower half becomes more or less curved and laterally compressed. The surface is longitudinally striated, but to the touch is smooth and slightly moist. There is no ring.

The *flesh* in both cap and stem is white at first, changing in maturity to light buff. In both taste and smell it faintly resembles the field mushroom.

Microscopic characters. The spores are white in mass; under the microscope either colourless or tinged a very pale buff. They are spherical; diameter 4 to 6 μ. Their wall is smooth and thin. Cystidia are absent, as is usual in Clitocybe. The cap surface is composed of ordinary parallel or branching hyphae, 2 to 5 μ broad. The basidia are 6 to 7 μ across, with four short sterigmata.

Discussion

Sytematic position. The large genus Clitocybe has been divided and classified by several mycologists, the first being Fries. In his classification, our species would fall under the sub-section Difformes, the first South African species to do so. Perhaps the most important of the modern revisions of the genus is that of Konrad et Maublanc (1948), by which it would come into their "Section 2. Orbiformes", in which the gills are "adnées, peu decurrentés", for the gills here are really only decurrent by a tooth, hardly more than adnate.

Poisonous properties. The Toxicology of this agaric has recently been investigated (Sapeika and Stephens 1965. p. 749). It has proved highly toxic to laboratory animals, though the active principle has not yet been identified. Though this does not necessarily mean that it is toxic to man, it certainly suggests that it is best avoided. This is a point of some practical importance, for the Hen and Chickens area is a favourite resort of Scouts, Guides and hikers, and the pinewood site itself is destined to be cut up for building plots.

Acknowledgments

I am deeply indebted to Mr. Frank Chapman, who brought this species to my notice and has collected regular supplies of material. Also to Mrs. Mary

Maytham Kidd for her life-like portraits of it.

I am also much indebted to Professor T. J. Haarhoff for assistance with the Latin diagnosis.

REFERENCE

KONRAD ET MAUBLANC: Agaricaceae. Encyclopédie mycologique Vol. XIV. Paris 1948.

LANGE, J. E.: Flora Agaricina Danica, Vol. I. Copenhagen 1935.

PEARSON, A. A.: Cape Agarics and Boleti (Trans. British Mycological Society, Vol. 33. 1950).

RIDGWAY, R.: Color Standards and Color Nomenclature. Washington. 1912.

SAPEIKA, N. & STEPHENS, E. L. Clitocybe toxica. S. African Medical Journal. September 1965. Vol. 39, pp. 749-750.

SINGER, ROLF.: The Agaricales in Modern Taxonomy. LILLOA: Revista de Botanico. Vol. XXII. 1949.

STEPHENS, E. L. & KIDD, M. M. Some South African Poisonous & Inedible Fungi. Longmans, 1953.

A DEFINITION AND NAME FOR AN EASTERN CAPE CRINUM

I. C. Verdoorn

Botanical Research Institute, Pretoria

Crinum macowanii subsp. **confusum** *Verdoorn* subsp. nov., a typica perianthii tubo lobis breviore, foliis semper glaucissimis paulum angustis undulatis humifusis differt.

Type: Albany, Carlisle Bridge near Grahamstown, *Archibald* 7513 (PRE, holo.).

Description

Bulbs subglobose, about 10 cm. diam., abruptly narrowed into a neck about 8 cm. long. *Leaves* sprawling along the ground, pale green, very glaucous, long, narrow, the median deeply canaliculate, about 40 cm. long, 0·5—5 cm. broad, undulate, margin with a narrow cartilaginous border and ciliate with a few weak distant cartilaginous hairs. *Peduncle* light green and glaucous, subcompressed, about 40 cm. long, 2 cm. wide, 1·3 cm. thick. *Umbel* about 14—25 flowered. *Spathe-valves*, 2 outer green becoming thin and parchment-like, 6·5 cm. long, 3 cm. broad at the base, inner narrow linear. *Pedicels* pale green, from about 3 cm. to 5 cm. long, suberect, straight; ovary bulge 1—2 cm. long. *Perianth* with the tube 3—5 cm. long, green, cernuous; segments white, dorsally suffused with rose, when faded turning light brown, conniving in a funnel shape with the apical third recurved, outer about 8 cm. long, 2·2 cm. broad about midway. *Stamens* with white filaments and black anthers. *Style* white with the apical upturned portion deep rose coloured; stigma terminal. *Capsule* oblong-obovate, about 5 cm. long and 4 cm. diam. in upper half, on long pedicels (up to 7 mm.), beak more or less 2·5 cm. long.

Occurs on loam or clay among karoo bushes or in open dry grassveld with scattered *Acacia karroo*. Recorded from the eastern Cape, from Albany district eastwards to Kentani and northwards to Queenstown district.

CAPE. Albany: Carlisle Bridge, near Grahamstown, *Archibald* 7513 (PRE. holotype); Dikkop Flats *Archibald* 7566. Bathurst: *Archibald* 5346, cult. King William's Town: near Berlin, *Comins* 1440; 1439. Cathcart: *McNeil* s.n. Queenstown: *Galpin* 2210. Komga: *Codd* 6349; *Flanagan* 624. Butterworth: *Pegler* 1802; *Dyer* 4509.

Early in the nineteenth century Ker-Gawler (according to Herbert, as will be pointed out below), confused this subspecies with *Crinum variabile*, a short-tubed species from Namaqualand. Herbert in turn, confused it with what he called "the common glaucous-leaved *C. capense*", and from his notes this included what is now known as *Crinum bulbispermum*, which although a glaucous-leaved species, is readily distinguished from our plant. In the National Herbarium, this plant has been confused both with typical *C. macowanii* and, when flowering material only was available, with *C. variabile* (Jacq.) Herb.; "confusum" was therefore the obvious choice for the epithet. The rank of subspecies was determined by the definite, restricted area of distribution and by the great variability of *C. macowanii*, the species to which it obviously belongs. Typical *Crinum macowanii* (see Journ. of S.A. Bot. 22 : 79, 1956) occurs in certain localities throughout the eastern Cape and northwards through Natal,

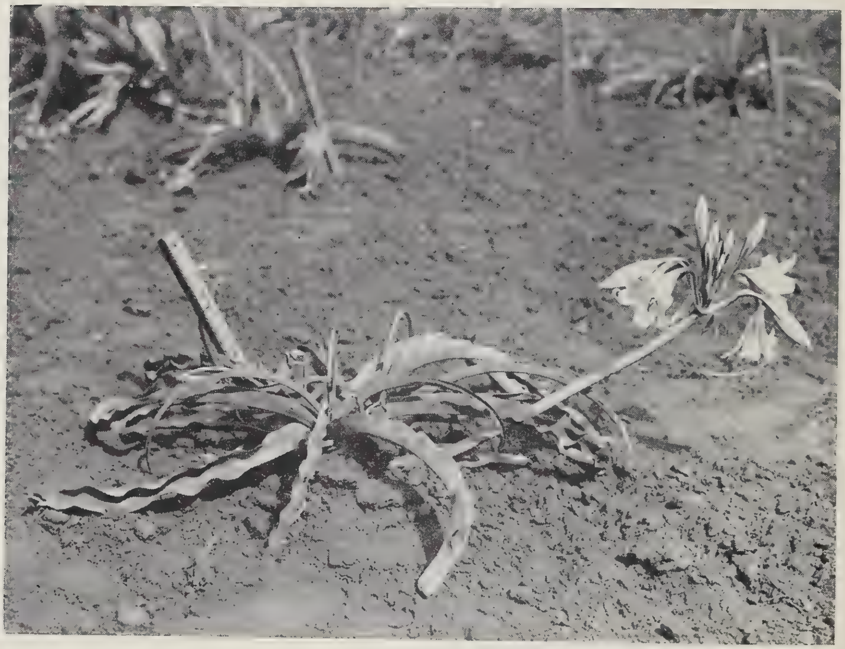


PLATE 1.

Crinum macowanii subsp. *confusum* Verdoorn. Originally from King William's Town district, Comins 1548. Cultivated at Pretoria. Leaves narrow, spreading; pedicels long, perianth-tube short. *Photo: J. Reyburn.*

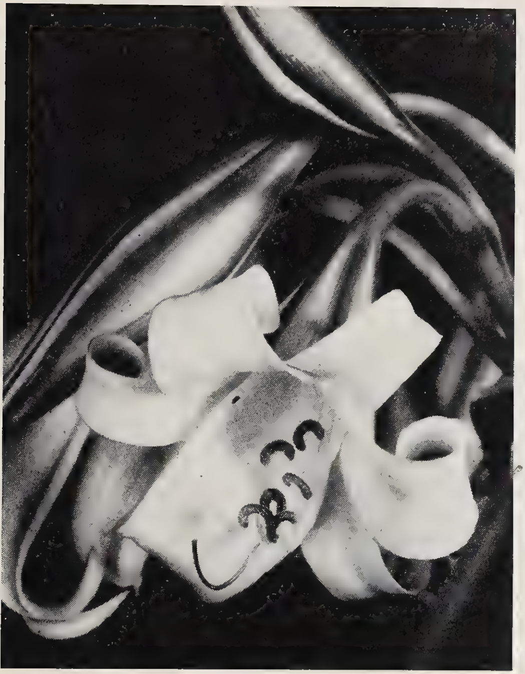


PLATE 2.
Crinum macowanii subsp. *confusum* Verdoorn. Originally from Carlisle Bridge, Archibald 7566. Cultivated at Pretoria. Close-up showing the long pedicel, the ovary swelling and the short perianth-tube. *Photo: J. Reyburn.*

the Orange Free State and Transvaal into the tropics. To date it has not been possible to circumscribe any of the many forms that are found and to give them infraspecific rank because the variation in the colour of the leaves and the size of the plant does not seem to be correlated with any other tangible difference. It is probable though that as the species becomes better known infraspecific units may be recognised, but they will no doubt be of lower rank than the form here described, because this form has, besides the definite area of distribution, what seems to be an inherent difference, a short perianth-tube, shorter than the lobes instead of one as long as or longer than the lobes. Moreover this feature is combined with leaves which are rather narrow, glaucous, flaccid and often markedly undulate and prostrate (Plate 1). But this leaf character alone does not distinguish it from the typical subspecies for some of its forms have very similar leaves.

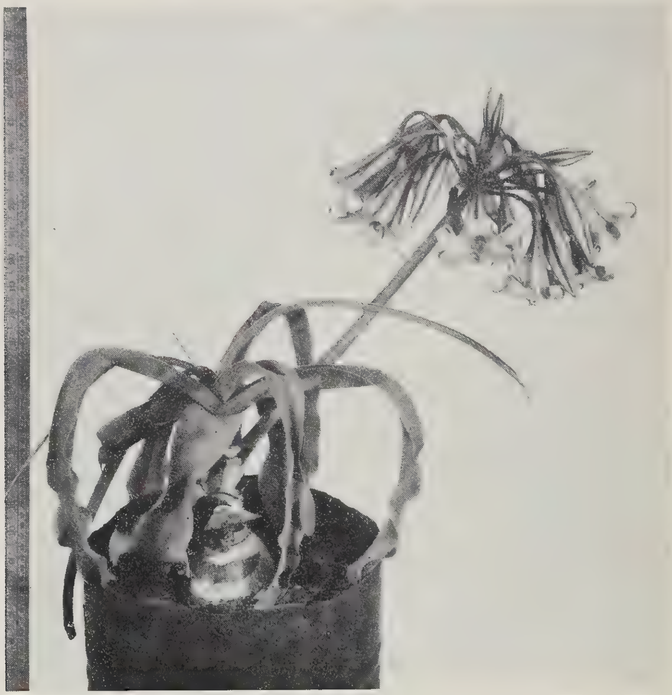


PLATE 3.
Crinum macowanii subsp. *confusum* Verdoorn. Originally from Carlisle Bridge, Archibald 7566. Cultivated at Pretoria. *Photo: J. Reyburn.*

The following is a brief history of the taxon as found in botanical publications. In 1809 Ker-Gawler published a figure of a short-tubed *Crinum*, matching the one here described, in the Botanical Magazine, Plate 1178, under the name *Amaryllis revoluta* (which, by the way, is a synonym of *C. lineare* L.). In 1822 he published a figure of a similar looking *Crinum*, Botanical Register plate 615, which he implied was the same species, and on this occasion described it as a variety of *Amaryllis revoluta*. Herbert in his "Amaryllidaceae" page 268, 1837, points out that, as he knows them, the specimen figured in the Botanical Magazine is not the same as the one figured later in the Botanical Register. The latter he determines as *Crinum variabile* (Jacq.) Herb. The former he claims differs in the flaccid glaucous leaves, instead of rather thick green leaves, and flowers which do not turn red as they fade. Herbert's views can now be confirmed. *C. variabile* is depicted on plate 1433 of Flowering Plants of Africa, Vol. 36. From that figure and description it will be seen that it differs from *C. macowanii* subsp. *confusum* here described, mainly in the very features mentioned by Herbert. There can be no doubt that these two short-tubed species are specifically distinct. As pointed out in Flowering Plants of Africa, *C. variable* occurs in the winter rainfall area while *C. macowanii* subsp. *confusum* is found in dry grassland or among karoo bushes in the eastern Cape.

We are indebted to Dr. E. A. Gledhill (nee Archibald) for supplying material and notes which assisted with the investigation of this taxon.

HAEMANTHUS CANALICULATUS,* A NEW FIRE-LILY FROM THE WESTERN CAPE PROVINCE

M. R. Levyns

During the latter part of December 1960 a disastrous fire swept through an area from Betty's Bay to Rooi Els. Before it was controlled, large stretches of country had been reduced to blackened wastes.

At the end of February, two months after the fire, the slopes, apart from an occasional Asparagus or Bobartia, were seemingly lifeless. However, in places where water had seeped down from the slopes, giving rise to marshy conditions, the situation was very different. Instead of black desolation numerous plants of Red Hot Poker (*Kniphofia uvaria*) with fully developed leaves and brilliantly coloured inflorescences, provided sheets of colour of breath-taking beauty. All the way from Rooi Els to Betty's Bay, whenever the soil was sufficiently moist, this wonderful display re-appeared.

A short distance from Rooi Els, Red Hot Pokers in abundance were growing close to the road. Among them were some brilliant red inflorescences of Haemanthus. At first they were taken to be a marsh form of the common *Haemanthus rotundifolius* but close examination suggested that this was not so. The colour was a more fiery red. The involucral bracts were longer, narrower and more pointed. When fully opened the bracts spread outwards instead of forming a cup. Later it became obvious that although its berries were similar they were much less fertile. Being hysteranthous, it was necessary to wait until after the winter rains had started for leaves to appear.

A second visit to the site was paid towards the end of June when a search for broad, flat leaves similar to those of *Haemanthus rotundifolius* was made. Nothing similar was found. In February relatively few species had made their appearance above the ground. Now it was very different. The old inflorescences had disappeared so that there was nothing to mark the exact spot where the species had been growing. Green shoots of innumerable plants had appeared, forming a dense, closed community. Anyone familiar with the tightly packed vegetation of a marsh in the western Cape, will realise the difficulties of a search

---

* *Paper read to Section B of the South African Association for the Advancement of Science at East London, July 1965.*

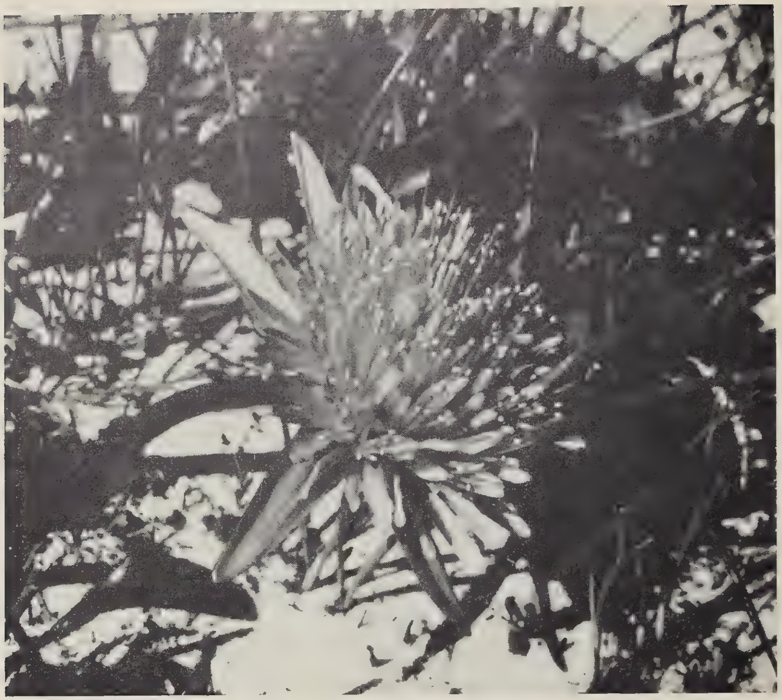


Plate 1.

Haemanthus canaliculatus sp. nov. In this specimen the peduncle made an acute angle with the ground. *Photo: J. E. P. Levyns.*

such as this. Eventually two fleshy, erect and very narrow leaves were found. Each leaf, due to the rolling of its edges, was deeptly channelled on the upper surface. They were so unlike any known leaves of Haemanthus, that only after a bulb had been dug up, was it certain that they belonged to a species of that genus. The characteristic overlapping storage leaves in two opposing rows, left no doubt about that. The green leaves at that time were about 18 cm. long. In one case three leaves were observed but the normal number seems to be two. Another visit to the area in October showed that the leaves had elongated considerably for the average length was now 36 cm. The diameter had not increased. In view of the very narrow channelled leaves it is proposed to name this species *Haemanthus canaliculatus.*

In going through the Incertae in the Bolus Herbarium it was discovered that this species had been found some years previously by Mrs. M. Brunt of Betty's Bay. Her specimen too, had been collected after a fire. During the Christmas holidays of the present year a small fire was started in the Betty's Bay area by small children playing with matches. Fortunately this was brought under control before it had spread far. A small damp hollow lay within the area and there in the later part of February Red Hot Pokers and this new species of Haemanthus were growing together. Most of the inflorescences were like those seen in 1961 near Rooi Els with the exception of two. One had unusually long pedicels, giving it a Nerine-like aspect. The other differed in colour, being pale pink.

Normally the peduncle stands erect but on both occasions a few plants were seen in which the peduncle made an acute angle with the ground. In one case it was lying more or less horizontally, thus suggesting that geotropism alone is not responsible for its position.

Up to the present no one has found the species excepting after fire and it seems likely that fire is needed to stimulate flowering.

Haemanthus canaliculatus sp. nov.

Herba bulbosa glaberrima. Bulbus diam. c. 9 cm., tunicis bifariis. Folia 2 vel interdum 3, hysterantha, anguste linearia, marginibus involutis, canaliculata, fere 36 cm. longa. Pedunculus crassus, roseus. Bracteae lanceolatae, paulo acutae, rubidae, patentes. Flores numerosi, conferti, rubidi. Perianthum tubo c. 5 mm. longo; lobis c. 20 mm. longis. Bacca globosa. Semen ovoideum, castaneum, nitidum.

TYPE: Levyns 11, 105 (in the Bolus Herbarium), marshy places above Rooi Els. Levyns 11, 140 and Levyns 11, 223 show the young and old leaves respectively and a bulb from plants growing in the same marshy spot as the type.

ACKNOWLEDGEMENT

I wish to express gratitude to my husband for his ever ready help. Patient search led him to the discovery of the leaves of this new species.

I also wish to thank Mr. A. Fricke for a print from which the illustration has been made. The original was a colour transparency.

A PAPER CHROMATOGRAPHIC SURVEY OF FREE AMINO ACIDS AND RELATED COMPOUNDS IN THE PROTEACEAE

J. van Staden

(*Department of Botany, University College of the Western Cape, Bellville, South Africa*)

Abstract

Fifty species of the Proteaceae, belonging to the genera *Brabeium*, *Paranomus*, *Serruria*, *Mimetes*, *Faurea*, *Protea*, *Leucospermum*, *Leucadendron* and *Aulax* were analysed for free ninhydrin-positive compounds by means of paper chromatography. Altogether 38 compounds, of which 19 could not be indentified, were found. Alanine, aspartic acid, cystine, γ-aminobutyric acid, glutamic acid, glutamine, glycine, phenylalanine, serine, threonine, tyrosine and valine occurred in most or all of the species examined. Pipecolic acid was identified in some species of *Protea* only. *Leucadendron* was the only genus containing citrulline in addition to arginine and ornithine; the urea cycle seems to operate in this genus. Although the unidentified compounds were usually present in relatively small amounts, three of them (U–3, U–4 and U–7) were of major importance in those species of *Protea* and *Faurea* in which they were found.

With the exception of the occurrence of citrulline, arginine and ornithine in *Leucadendron*, the distribution of ninhydrin-positive compounds seems to have little taxonomic significance.

Introduction

The use of paper chromatography has led to the discovery and identification of many amino acids and related compounds in plants, e.g., pipecolic acid (Zacharius, Thompson and Steward, 1954), γ-methylene glutamine and γ-methylene glutamic acid (Zacharius, Pollard and Steward, 1952), and azetidine-2-carboxylic acid (Fowden, 1955). Many substances have not been identified, however. In 1955, Steward, Zacharius and Pollard recorded the occurrence of 85 known and 84 unidentified nitrogenous compounds in nature.

Systematic chromatographic surveys have been made of the nitrogenous compounds in certain plant groups, e.g., hops (Harris and Tatchell, 1953), the marine algae (Coulson, 1953), and the Liliaceae (Fowden and Steward, 1957). Some of these surveys have supplied information regarding the possible occurrence of new or unusual metabolic pathways (Fowden and Steward, 1957). The information obtained in this way has also been used to study possible chemical taxonomic relationships.

TABLE 1.

List of species examined

Ref. No.	*Species*
Br–1	Brabeium stellatifolium Linn.
Pa–1	Paranomus crithmifolia R. Br.
Pa–2	P. reflexa Phillips & Hutchinson.
Se–1	Serruria artemisiaefolia Knight.
Se–2	S. burmanni R. Br.
Se–3	S. florida Knight.
Mi–1	Mimetes lyrigera Knight.
Fa–1	Faurea magnaughtonii Phillips.
Pr–1	Protea acaulis Thunb.
Pr–2	P. arborea Houtt.
Pr–3	P. barbigera Meisn.
Pr–4	P. cedromontana Schlechter.
Pr–5	P. compacta R. Br.
Pr–6	P. cordata Thunb.
Pr–7	P. cynaroides Linn.
Pr–8	P. grandiceps Tratt.
Pr–9	P. incompta R. Br.
Pr–10	P. lanceolata E. Mey.
Pr–11	P. eximia (Salisb. ex Knight) Fourc. (P. latifolia R. Br.).
Pr–12	P. laurifolia Thunb.
Pr–13	P. longiflora Lam.
Pr–14	P. nana Thunb.
Pr–15	P. neriifolia R. Br.
Pr–16	P. obtusifolia Buek.
Pr–17	P. odorata Thunb.
Pr–18	P. repens (Linn.) Linn. non Thunb.
Pr–19	P. scolymocephala Reichard.
Pr–20	P. susannae Phillips.
Ls–1	Leucospermum attenuatum R. Br.
Ls–2	L. candicans Loud.
Ls–3	L. catherinae Compton.
Ls–4	L. conocarpum R. Br.
Ls–5	L. linearé R. Br.
Ls–6	L. murii Phillips.
Ls–7	L. nutans R. Br.
Ls–8	L. patersonii Phillips.
Ls–9	L. prostratum Stapf.
Ls–10	L. oleaefolium R. Br.
Ls–11	L. reflexum Buek.
Ld–1	Leucadendron adscendens R. Br.
Ld–2	L. argenteum R. Br.
Ld–3	L. concinnum R. Br.
Ld–4	L. daphnoides Meisn.
Ld–5	L. decorum R. Br.
Ld–6	L. discolor Buek.
Ld–7	L. grandiflorum R. Br.
Ld–8	L. salignum R. Br.
Ld–9	L. sericocephalum Schlechter.
Au–1	Aulax cneorifolia Knight.
Au–2	A. pinifolia Berg.

The Proteaceae constitute an important South African family of the flowering plants. Relatively little is known about their chemical composition, particularly in regard to soluble nitrogenous constituents. The occurrence and distribution of some soluble nitrogenous compounds in a number of species of the Proteaceae were therefore investigated. It was also hoped to determine whether the distribution of these substances might be of any taxomic significance.

MATERIAL AND METHODS

Fifty species, belonging to nine genera of the Proteaceae, viz., *Brabeium*, *Paranomus*, *Serruria*, *Mimetes*, *Faurea*, *Protea*, *Leucospermum*, *Leucadendron* and *Aulax*, were examined. The plants were collected and identified at the National Botanic Gardens, Kirstenbosch. The different species, together with their reference numbers, are listed in Table 1. The genera are arranged according to the classification of Engler and Prantl (1893).

Healthy, approximately one-year-old leaves were collected on the 25th February, 1964, from plants growing in the National Botanic Gardens, Kirstenbosch. The leaves were put in polyethylene bags and stored at -9°C until required for analysis. The soluble nitrogenous fraction was obtained as follows: Ten grams of leaf material were macerated in a Waring blendor with sufficient absolute ethanol to give a final concentration of 80% ethanol. The homogenate was filtered and the residue washed with an additional 100 ml 80% ethanol. Pigments and lipids were removed by shaking the combined filtrate with three volumes of chloroform and separating off the aqueous layer, containing the soluble nitrogenous fraction (Dörfel, 1958). Amino acids and amides were removed from the aqueous extract by passing it through a column of Amberlite IR–120 resin (H^+ form), washing the column with deionised water and eluting them from the resin with 2N NH_4OH until the eluate gave a negative test with ninhydrin. The eluate was concentrated to dryness *in vacuo* at a temperature below 40°C and the residue dissolved in two ml 10% isopropanol.

A 350 μl aliquot of each extract was chromatographed two-dimensionally on Whatman No. 1 chromatography paper, with phenol:water (8 : 2; v/v, adjusted to pH 5·5 with NaOH) in the first (short) and n-butanol:acetic acid: water (4:1:1; v/v) in the second dimension for 22 hours. The chromatograms were dried, sprayed with 0·25% ninhydrin in acetone, and finally dried at 60°C. During the development of the chromatograms the temperature in the laboratory ranged between 18 and 29°C. Although it affected the chromatograms, the separations were always sufficient to distinguish among the different compounds.

The above procedure was employed for the separation and identification of ninhydrin-positive substances as well as for the estimation of their relative concentrations. These were judged according to the relative sizes and intensities of the ninhydrin-reacting spots, and were expressed in terms of an arbitrary scale from one to five, ranging from a trace upwards (see Tables 2 to 5). Wherever necessary, the ninhydrin-reacting spots were identified by means of

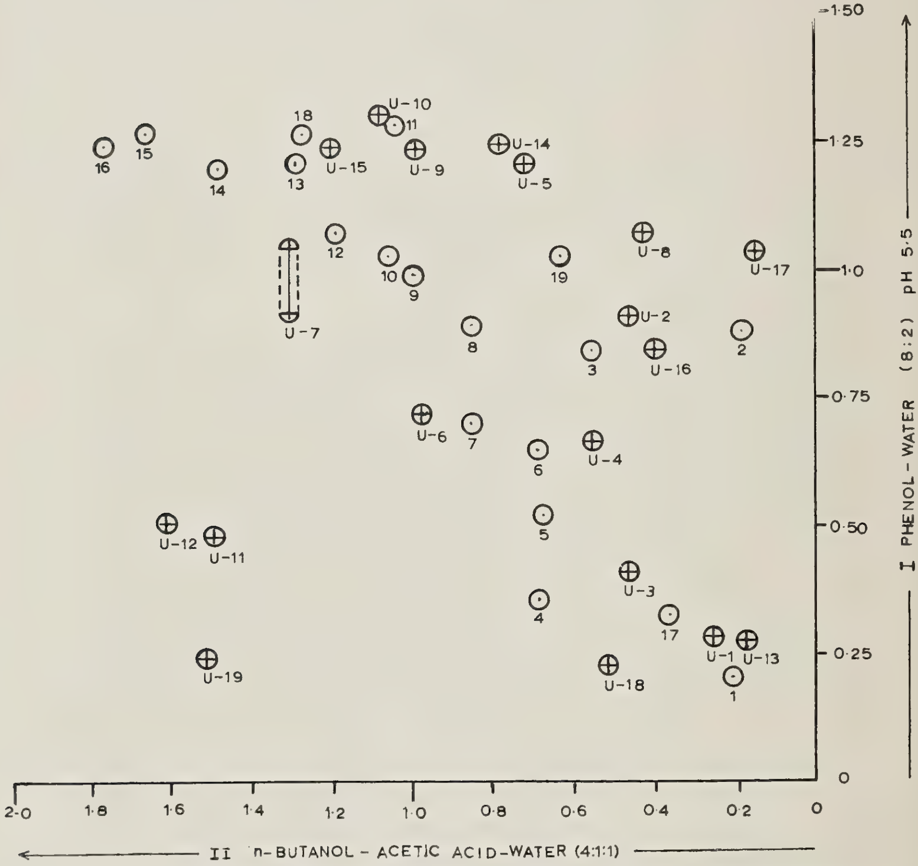


FIG. 1. Positions of free ninhydrin-positive compounds found in the Proteaceae (R-alanine values indicated along abscissa and ordinate):
1—cystine; 2—arginine; 3—glutamine; 4—aspartic acid; 5—serine; 6—glycine; 7—glutamic acid; 8—threonine; 9—alanine; 10—β-alanine; 11—proline; 12—tyrosine; 13—γ-aminobutyric acid; 14—valine; 15—phenylalanine; 16—leucine/isoleucine; 17—ornithine; 18—pipecolic acid; 19—citrulline; U-1 to U-19—unidentified substances. ⊙ — identifiable compounds; ⊕ — unidentified compounds.

TABLE 2.

Relative concentrations of ninhydrin-positive compounds in Brabeium, Paranomus, Serruria, Mimetes, Faurea and Aulax*

Compound		Species Reference No. **									
		Br–1	Pa–1	Pa–2	Se–1	Se–2	Se–3	Mi–1	Fa–1	Au–1	Au–2
Alanine		5	4	5	4	4	4	3	4	4	3
Arginine		–	–	–	–	–	–	–	1	–	–
Aspartic acid		2	3	3	4	2	4	3	2	3	2
β-alanine		–	1	1	–	1	1	–	–	–	–
Cystine		1	2	2	2	1	2	2	1	2	2
γ-aminobutyric acid		4	4	4	4	4	4	3	5	4	4
Glutamic acid		4	5	4	5	5	4	5	4	5	5
Glutamine		2	2	3	2	2	3	2	2	3	1
Glycine		2	3	3	4	3	3	3	3	3	2
Leucine/isoleucine		–	–	1	–	–	–	–	–	–	–
Phenylalanine		2	2	2	2	1	2	1	2	2	1
Proline		–	–	–	1	–	–	–	–	–	–
Serine		3	3	3	4	3	4	3	3	4	3
Threonine		2	2	2	2	2	3	2	2	2	1
Tyrosine		3	2	–	2	1	2	2	3	1	–
Valine		2	2	2	2	2	2	2	2	2	1
Unidentified	U–1	–	–	–	–	–	–	–	–	–	2
	U–2	–	–	–	–	–	–	–	–	1	–
	U–3	–	–	–	–	–	–	–	3	–	–
	U–4	–	–	–	–	–	–	–	3	–	–
	U–5	–	1	1	1	1	1	–	–	–	–
	U–6	–	–	–	–	–	–	–	–	2	–
	U–7	–	–	–	–	–	–	–	4	–	–

*Relative concentrations: 1 = Trace reaction; 2 = Weakly reacting; 3 = Moderately reacting; 4 = Strongly reacting; 5 = Major constituent.
**See Table 1.

TABLE 3.

Relative concentrations of ninhydrin-positive compounds in different species of Protea*

Compound		Species Reference No. Pr**																			
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Alanine		4	3	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	5	4	4
Arginine		–	1	–	–	–	–	–	–	–	2	–	–	–	1	–	–	–	–	1	–
Aspartic acid		3	2	3	3	4	2	3	3	3	3	3	2	4	4	3	3	3	2	3	3
β-alanine		–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Cystine		1	1	1	1	2	1	2	2	1	2	1	1	2	2	1	2	1	1	2	1
γ-aminobutyric acid		4	3	4	4	3	4	3	4	3	4	4	4	4	4	4	4	3	4	3	4
Glutamic acid		4	5	4	4	5	5	5	5	5	5	4	5	5	5	5	4	5	4	5	5
Glutamine		2	1	2	2	1	3	1	2	1	3	2	1	3	1	1	1	3	2	2	1
Glycine		3	3	2	3	3	1	2	3	2	3	3	2	3	2	3	2	3	3	3	2
Leucine/isoleucine		–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Ornithine		–	1	–	1	2	–	2	2	–	–	–	–	–	–	–	2	–	–	–	1
Phenylalanine		1	1	2	1	2	2	2	1	2	2	1	1	1	2	1	1	2	1	1	1
Pipecolic acid		–	2	2	–	–	4	2	2	3	3	–	–	–	1	–	2	–	–	–	–
Serine		3	3	3	3	3	3	3	3	3	4	3	3	4	3	3	3	4	3	3	4
Threonine		2	2	1	2	2	2	2	1	2	3	2	2	3	1	2	2	3	2	2	2
Tyrosine		3	3	1	2	–	2	3	3	3	3	2	1	1	3	–	3	2	2	2	1
Valine		2	1	2	1	2	2	2	1	1	2	1	2	1	2	1	1	2	1	2	1
Unidentified:	U–3	4	–	–	–	–	4	4	4	–	–	–	–	–	4	–	4	–	–	3	–
	U–4	4	–	–	–	–	4	4	4	–	–	–	–	–	4	–	4	–	–	3	–
	U–7	5	5	5	–	–	–	5	5	–	–	–	–	–	–	–	5	5	–	–	–
	U–8	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	–	–	–
	U–9	–	2	2	–	–	–	2	–	–	2	–	–	–	–	–	2	–	–	–	–
	U–10	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–
	U–11	–	–	–	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	U–12	–	–	2	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–

*See subscript to Table 2.
**See Table 1.

co-chromatography or specific spray reagents (Block, Durrum and Zweig, 1958). Where compounds could not be positively identified, they were numbered and their R-alanine values in each of the solvents noted, along with the colour produced with ninhydrin.

RESULTS

The positions of the different ninhydrin-reacting compounds observed on the chromatograms are shown in figure 1. Each spot represents the average of all R-alanine values obtained for the particular compound. The relative concentrations of the various ninhydrin-positive substances found in the different species are listed in Tables 2 to 4. Their frequencies in the different genera are summarised in Table 5. The ninhydrin colours and R-alanine values of the unidentified compounds are given in Table 6.

Altogether 38 ninhydrin-positive substances were found; 19 of these could not be identified. Alanine, γ-aminobutyric acid, aspartic acid, glutamine and serine were present in extracts from all species in moderate to relatively high amounts. Glutamic acid tended to be the major free amino acid. Cystine,

TABLE 4.

Relative concentrations of ninhydrin-positive compounds in species of Leucospermum and Leucadendron*

	Species Reference No.**																			
	Leucospermum (Ls)											Leucadendron (Ld)								
Compound	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5	6	7	8	9
Alanine	4	4	4	4	4	5	4	5	5	4	5	4	4	4	4	3	4	4	4	4
Arginine	–	1	–	–	–	–	1	1	2	1	–	1	2	1	1	1	1	1	2	1
Aspartic acid	3	3	3	3	3	3	3	3	4	4	2	4	3	3	3	4	2	3	4	4
β-alanine	–	1	1	–	–	1	1	1	1	2	1	–	–	–	–	–	–	–	–	–
Citrulline	–	–	–	–	–	–	–	–	–	–	–	–	2	3	–	3	1	1	1	1
Cystine	1	2	2	1	2	1	2	2	1	1	1	2	2	2	2	3	3	2	2	2
γ-aminobutyric acid	4	4	4	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Glutamic acid	5	5	4	4	5	4	5	3	4	4	4	4	4	4	4	4	4	4	4	4
Glutamine	2	2	4	2	2	2	2	2	2	4	2	1	2	2	1	2	1	2	1	2
Glycine	3	2	3	3	3	3	3	2	2	3	3	2	2	2	2	3	3	2	2	2
Leucine/isoleucine	–	–	2	–	2	–	–	2	2	–	–	–	–	–	–	–	–	–	–	–
Ornithine	–	–	–	–	–	1	–	–	–	–	–	2	1	2	2	3	2	1	2	1
Phenylalanine	1	2	2	2	2	2	2	2	2	2	2	–	3	2	–	2	1	2	3	2
Proline	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Serine	2	3	4	4	4	3	3	3	3	3	2	3	4	2	2	4	3	4	2	2
Threonine	2	3	2	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3
Tyrosine	–	1	–	1	3	1	1	–	–	–	–	2	3	2	1	3	1	2	2	2
Valine	2	2	2	2	2	2	2	2	2	2	2	2	2	2	–	1	1	1	1	2
Unidentified: U–5	–	1	–	–	–	1	1	1	–	–	1	–	–	–	–	–	–	–	–	–
U–8	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3	–	1	2	1
U–13	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
U–14	–	–	1	–	1	1	1	–	–	–	–	–	–	–	–	–	–	–	–	–
U–15	–	1	–	–	–	1	1	–	–	–	–	–	–	–	–	–	–	–	–	–
U–16	–	–	–	–	2	1	–	–	–	–	1	–	–	–	–	–	–	–	–	–
U–17	–	–	–	–	–	–	–	–	–	–	–	1	1	1	–	1	1	1	1	1
U–18	–	–	–	–	–	–	–	–	–	–	–	–	2	2	2	–	1	3	3	3
U–19	–	–	–	–	–	–	–	–	–	–	–	–	3	–	–	–	–	–	–	–

* See subscript to Table 2.
** See Table 1.

TABLE 5.

Frequency percentages of different ninhydrin-positive substances in different genera of the Proteaceae

Compound	Brabeium*	Paranomus	Serruria	Mimetes*	Faurea*	Protea	Leucospermum	Leucadendron	Aulax
Alanine	100	100	100	100	100	100	100	100	100
Arginine	0	0	0	0	100	20	45	100	0
Aspartic acid	100	100	100	100	100	100	100	100	100
β-alanine	0	100	67	0	0	5	73	0	0
Citrulline	0	0	0	0	0	0	0	78	0
Cystine	100	100	100	100	100	100	100	100	100
γ-aminobutyric acid	100	100	100	100	100	100	100	100	100
Glutamic acid	100	100	100	100	100	100	100	100	100
Glutamine	100	100	100	100	100	100	100	100	100
Glycine	100	100	100	100	100	100	100	100	100
Leucine/isoleucine	0	50	0	0	0	5	36	0	0
Ornithine	0	0	0	0	0	35	9	100	0
Phenylalanine	100	100	100	100	100	100	100	78	100
Pipecolic acid	0	0	0	0	0	45	0	0	0
Proline	0	0	33	0	0	0	9	0	0
Serine	100	100	100	100	100	100	100	100	100
Threonine	100	100	100	100	100	100	100	100	100
Tyrosine	100	50	100	100	100	90	45	100	50
Valine	100	100	100	100	100	100	100	89	100
Unknowns: U–1	0	0	0	0	0	0	0	0	50
U–2	0	0	0	0	0	0	0	0	50
U–3	0	0	0	0	100	35	0	0	0
U–4	0	0	0	0	100	35	0	0	0
U–5	0	100	100	0	0	0	45	0	0
U–6	0	0	0	0	0	0	0	0	50
U–7	0	0	0	0	100	35	0	0	0
U–8	0	0	0	0	0	5	0	44	0
U–9	0	0	0	0	0	25	0	0	0
U–10	0	0	0	0	0	5	0	0	0
U–11	0	0	0	0	0	5	0	0	0
U–12	0	0	0	0	0	10	0	0	0
U–13	0	0	0	0	0	0	9	0	0
U–14	0	0	0	0	0	0	36	0	0
U–15	0	0	0	0	0	0	27	0	0
U–16	0	0	0	0	0	0	27	0	0
U–17	0	0	0	0	0	0	0	89	0
U–18	0	0	0	0	0	0	0	78	0
U–19	0	0	0	0	0	0	0	11	0

* Only one species examined.

glycine, phenylalanine, threonine, tyrosine and valine occurred in most or all of the extracts, but generally at lower levels than the former group. Three components of the urea cycle were identified: arginine and ornithine occurred in some species of *Protea* and *Leucospermum*, but generally not together in the same species; relatively small amounts of arginine and ornithine were present in all species of *Leucadendron*, and citrulline in most of them. This was the

TABLE 6.

Colour changes and R-alanine values of unidentified ninhydrin-positive substances

Unidentified Compound No.	Ninhydrin colour*	R-alanine values in: Phenol/water	R-alanine values in: Butanol/acetic acid/water
U–1	P	0.28	0.25
U–2	P	0.91	0.46
U–3	Y–P	0.42	0.46
U–4	Y–P	0.67	0.55
U–5	P	1.21	0.72
U–6	P	0.73	0.97
U–7	YB–B–P	0.98	1.31
U–8	P	1.08	0.42
U–9	P	1.24	0.99
U–10	P	1.31	1.08
U–11	P	0.48	1.49
U–12	P	0.51	1.61
U–13	P	0.28	0.17
U–14	P	1.25	0.79
U–15	P	0.28	1.20
U–16	P	0.85	0.40
U–17	P	1.04	0.14
U–18	P	0.17	0.52
U–19	P	0.24	1.51

* Colours: P = purple; YB = yellow-brown; Y = yellow; B = brown.

only genus in which citrulline was observed. Pipecolic acid was identified in a number of *Protea* species only. Glutamine, the only amide identified, was present in low to moderate amounts in all species. Leucine-isoleucine and proline were observed in only a few species.

The unidentified substances were not widely distributed. No unidentifiable compounds were found in *Brabeium stellatifolium* (Br–1), *Mimetes lyrigera* (Mi–1), eight *Protea* and four *Leucospermum* species. One compound, U–5, was found in altogether 10 species of *Paranomus*, *Serruria* and *Leucospermum*. U–8 occurred in one species of *Protea* and four of *Leucadendron*, and U–3, U–4 and U–7 in *Faurea magnaughtonii* and some *Protea* species in fairly large amounts, with the former two always together. The other unidentifiable substances (U–1, U–2, U–6 and U–9 to U–19) were found in only one genus each.

Three of the unidentified compounds, viz., U–3, U–4 and U–7, underwent marked colour changes within 12 hours after spraying with ninhydrin: U–3 and U–4 changed from yellow to purple, and U–7 from yellowish-brown through brown to purple. Judging from the intensity of the ninhydrin colour and spot size, U–7 appeared to be the major free ninhydrin-positive compound in those species in which it was present.

DISCUSSION

Although some 50 species of the Proteaceae were analysed, no specific distribution pattern of ninhydrin-positive substances could be recognised for the family as such. Practically all the species examined contained alanine, aspartic acid, cystine, γ-aminobutyric acid, glutamic acid, glutamine, glycine, phenylalanine, serine, threonine and valine in varying amounts. It is doubtful, however, whether this composition would distinguish the Proteaceae from other families.

When one considers the individual genera, *Leucadendron* differs from the rest in that it is the only genus containing citrulline; in addition, it is the only genus in which three components of the urea cycle, viz., arginine, citrulline and ornithine, occur fairly consistently. The two unknown compounds U–17 and U–18, although present in very small amounts, might also be typical of *Leucadendron.*

Although arginine and ornithine occur in *Protea*, their frequencies are too low for them to be regarded as distinctive. The fact that pipecolic acid was found in some *Protea* spp. is of interest, but because of its low frequency it cannot be used to distinguish *Protea* from other genera of this family. Pipecolic acid might have been present in some other genera and species, because its identification is complicated by the fact that it does not separate completely from γ-aminobutyric acid.

Although the relatively high concentrations of the unknowns U–3, U–4 and U–7 in *Protea* and *Faurea* make them interesting from a biochemical viewpoint, their presence is of doubtful taxonomic value because of their low frequencies in *Protea* and the fact that only one species of *Faurea* was analysed. The other unknown substances occurred in only one genus each, but with the exception of U–17 and U–18 in *Leucadendron*, their distribution was too sporadic or too few species were examined for them to be of any taxonomic value.

It would appear, therefore, that with the exception of the components of the urea cycle (particularly citrulline) found in *Leucadendron*, no particular and consistent distribution pattern of free ninhydrin-reacting compounds could be observed in the Proteaceae. The occurrence of arginine, citrulline and ornithine in *Leucadendron* is of both biochemical and taxonomic interest, but more species will have to be examined and attempts made to identify the unknown compounds, before a complete picture of the free amino acids in the Proteaceae and their taxonomic significance (if any) can be obtained. The possibility that nutritional and environmental factors may affect the occurrence and concentration of these compounds must also be considered.

ACKNOWLEDGEMENTS

The author wishes to thank dr. J. A. de Bruyn for his assistance with the preparation of the manuscript, and prof. E. D. Garber for critically reading the manuscript.

REFERENCES

BLOCK, R. J., DURRUM, E. L., and ZWEIG, G. (1958): *A Manual of Paper Chromatography and Paper Electrophoresis*. 2d Ed. Academic Press, New York.

COULSON, C. B. (1953): Amino-acids of marine algae. Chem. & Ind.: 971–972.

DÖRFEL, H. (1958): Proteine und ihre Bausteine. In: *Papier-chromatographie in der Botanik* (Ed.: H. F. Linskens), 2. Aufl., pp. 148–198. Springer-Verlag, Berlin.

ENGLER, A. and PRANTL, K. (1893): *Die Natürlichen Pflanzenfamilien*, Bd III, Teil 1. Verlag Wilhelm Engelmann, Leipzig.

FOWDEN, L. (1955): Azetidine-2-carboxylic acid: a new constituent of plants. Nature **176**: 347–348.

FOWDEN, L. and STEWARD, F. C. (1957): Nitrogenous compounds and nitrogen metabolism in the Liliaceae. I. The occurrence of soluble nitrogenous compounds. Ann. Bot. (N.S.) **21** : 53–67.

HARRIS, G. and TATCHELL, A. R. (1953): Amino acids and peptides of hops and wort. III. The amino acids of fresh hops. J. Inst. Brewing **59** : 371–377.

STEWARD, F. C. and POLLARD, J. K. (1957): Nitrogen metabolism in plants: Ten years in retrospect. Annu. Rev. Plant Physiol. **8** : 65–114.

STEWARD, F. C., ZACHARIUS, R. M. and POLLARD, J. K. (1955): Nitrogenous compounds in plants: Recent knowledge derived from paper partition chromatography. Ann. Acad. Sci. Fennicae, Ser. A, II, **60** : 321–366.

ZACHARIUS, R. M., THOMPSON, J. F. and STEWARD, F. C. (1952): The detection, isolation, and identification of (–)-pipecolic acid as a constituent of plants. J. Amer. Chem. Soc. **74** : 2949.

ZACHARIUS, R. M., POLLARD, J. K. and STEWARD, F. C. (1954): γ-Methylene glutamine and γ-methylene glutamic acid in the tulip (*Tulipa gesneriana*). J. Amer. Chem. Soc. **76** : 1961–1962.

STUDIES IN STREPTOCARPUS

O. M. HILLIARD

(*Bews Botanical Laboratories, University of Natal, Pietermaritzburg*)

ABSTRACT

A brief account is given of the habitat, habit, and floral morphology of *Streptocarpus* in South Africa, and a more natural grouping than the present subdivision into *Unifoliati* and *Rosulati* is outlined. Attention is drawn to the prevalence of natural interspecific hybridisation and its obvious and inferred effect upon morphological variation. The taxonomy of *S. polyanthus* and its allies is dealt with.

The subgenus Streptocarpus in South East Africa

Streptocarpus is divided into two subgenera. Subgenus *Streptocarpus* extends from Tropical Africa southwards to the eastern Cape, while subgenus *Streptocarpella*, widespread in Tropical Africa, is unrecorded south of Malawi. Only the south eastern representatives of *Streptocarpus* will be dealt with in these studies.

The last account of *Streptocarpus* in South Africa was that of Clarke (1904). Since then a number of new species have been described and much comment made on existing species. Clarke's work was based largely on herbarium material and his, and subsequent, descriptions were often inaccurate and inadequate. Determination of specimens was thus difficult and application of names doubtful.

An attempt was therefore made to solve the taxonomic problems relating to the Natal taxa as these were, to me, the most pressing. It soon became apparent that many species are extremely variable. As work progressed, patterns of affinity between the species began to emerge. It eventually proved possible to divide the subgenus into one or two isolated species and a number of groups of closely related taxa, each group delimited by clearcut diagnostic characters and sometimes possessing a distinctive facies.

It is proposed to publish a series of papers containing descriptions of and keys to some of the species, and in addition, their synonymy and literature, and such discussion on variation, interspecific hybridisation, habit, habitat and distribution, as seems necessary to clarify immediate taxonomic problems. The purpose of the series will be to facilitate correct application of existing names, and to provide accurate, detailed and uniform descriptions of both "old" and "new" species.

I have seen all cited specimens. In addition to the herbarium abbreviations of Lanjouw and Stafleu (1964), SGH denotes Swaziland Government Herbarium, Mbabane, Swaziland.

An asterisk against a literature reference indicates an illustration accompanying the text.

HABITAT

The subgenus is not confined to shady wooded kloofs at high altitudes as is popularly supposed (cf. Lawrence 1940, 1958). Preferences are for partial shade with moisture from rain, seepage or mist. These requirements are fulfilled not only by forest conditions but also by cliffs, escarpments and rock outcrops, generally those orientated south west to south east, which face the rainbearing winds and are partially shaded during the day. Such rock habitats abound in eastern South Africa, and together with forest and forest patches are found throughout the area from almost sea level to about 2,300 m. Above this altitude, climatic conditions are possibly unsuitable for *Streptocarpus*.

Some species are restricted to forest, some to rock habitats, and a few are able to adapt themselves to both. Even in forest, habitat preference is for rock outcrops, cliffs, and steep earth banks. Many forest species may grow epiphytically; some are invariably epiphytic or lithophytic. Good drainage is probably a critical factor, since species otherwise difficult to cultivate grow well in hanging baskets.

Factors governing geographical distribution are obscure. Altitude with its effect upon climate appears to be of significance in some instances, for example *S. pentherianus* Fritsch grows at altitudes generally greater than 1,200 m and ranges along the Drakensberg, its foothills and outliers from the Cape-Natal border to the south eastern Transvaal and Swaziland. *S. pusillus* Harv. ex C.B.Cl. occurs above about 1,675 m on the Cave Sandstone of the Drakensberg in Natal, Basutoland and Orange Free State and at slightly lower altitudes in the eastern Cape. *S. fanniniae* Harv. ex C.B.Cl. is found only above 900 m in the Mistbelt forests of Natal. On the other hand, *S. gardeni* Hook. grows in forested areas from the eastern Cape to northern Natal from the Drakensberg virtually to the coast.

HABIT

In *Streptocarpus* the embryo, consisting of two cotyledons, a hypocotyl and a radicle, has no plumular bud. Shortly after germination, one cotyledon aborts, and the other proliferates from a basal meristem to produce a foliaceous organ here referred to as a "leaf". The hypocotyl may or may not form a conspicuous stalk to the leaf. The radicle is replaced by a fibrous root system.

The vegetative plant may consist of only this solitary leaf with its fibrous roots. Inflorescences develop in acropetal succession from the upper surface of the leaf at the base of the midrib. After flowering and fruiting, the whole plant dies. Species exhibiting this growth form are monocarpic.

In other species, however, one or several accessory leaves develop from the meristem, generally opposite the primary leaf, from which they are indistinguishable. Usually, each leaf is monocarpic, and is succeeded by other accessory leaves. Occasionally a leaf may persist for two seasons, shown by the presence of old infructescences adjacent to new flowering peduncles. Species exhibiting this growth form are perennial (polycarpic).

In still other species, however, the cotyledonary leaf elongates and becomes petiolate. The petiole is often curved at the base, producing adventitious roots where it touches the ground. Other petiolate leaves develop near the base of the first petiole, and in this way a loose association of petiolate, rooting leaves is built up—the so-called rosette, in which each individual leaf is monocarpic,

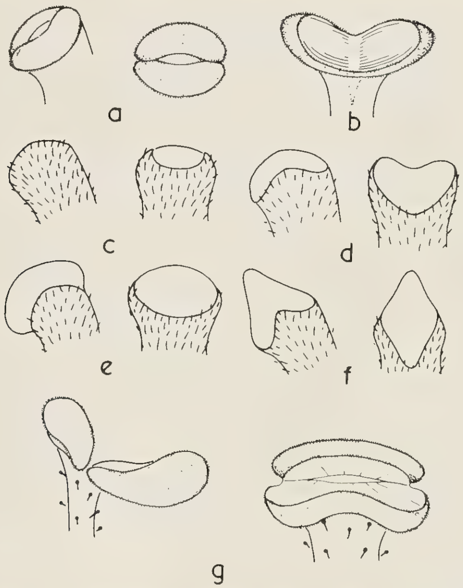


FIG. 1. Stigma forms in the subgenus *Streptocarpus*. a. Stomatomorphic, papillose stigma viewed from the side and from above. b. Stigma of two equal, lingulate, papillose lips. c—e. Truncate to subcapitate stigmas, side and front views. f. Conical stigma, side and front views. g. Stigma of two unequal, reniform, papillose lips, side and front views.

but the plant is perennial. Britten (1940) reported that some strains of the rosulate *S. rexii* (Lindl.) Hook. and *S. johannis* L. L. Britten increase vegetatively by the adventitious sprouting of leaves from roots. *S. cyaneus* S. Moore and *S. primulifolius* Gandoger, also rosulate, habitually develop a rhizomatous organ about a centimetre in diameter, sometimes branched, and attaining a length of several centimetres. This "rhizome" has numerous leaf scars and bears a tuft of leaves at its apex. Rhizome development is possibly correlated with habitat; this organ is developed in species favouring rock faces.

The distinction between monocarpic (one-leaved) and perennial (several-leaved) plants is not absolute. Lawrence (1958), in commenting on the work of Oehlkers (1938, 1942) made the observation "[it appears] as if two dominant supplementary genes controlled the rosulate character, the double recessive being unifoliate. Clearly, if modifiers affect either or both of the recessive genes, or if they differ in their degree of recessiveness, the possibility exists of unifoliates . . . producing a second leaf of sorts."

This is borne out by field observations. In solitary-leaved and therefore monocarpic species, the meristem occasionally gives rise to a foliaceous bract resembling an accessory leaf. This may or may not produce small peduncles, the whole plant dying after flowering.

In *S. pusillus*, one, sometimes two, petiolate flowering leaves are often produced opposite the primary leaf but the plant is monocarpic. *S. davyi* S. Moore has the same growth form, but accessory leaves also arise at the base of the primary petiole and the plant is perennial. Other species (e.g. *S. dunnii* Hook. f. and *S. galpini* Hook. f.) are often unifoliate, but sometimes produce several leaves. That they are perennial is doubtful, because of the absence of old leaf and peduncle remains evident in the true perennials. The problem of whether solitary-leaved taxa are always monocarpic and several-leaved taxa always perennial, needs further investigation.

A similar problem arises if the meristem is damaged and proliferation occurs. The plant may survive for more than one season but is not truly perennial.

DIAGNOSTIC CRITERIA

In some species, morphological variation is pronounced, consequently the recognition of species limits is not always easy. An appreciation of variation patterns was arrived at only after sampling numerous populations. In some variable species, this led to the recognition of infra-specific taxa, but in others no such subdivision was possible.*

---

* The sampling method used was to select flowers of similar age, one from each of twenty plants within a population, at intervals determined by population extent. The corollas were photographed against a centimetre scale, then pressed. The pressed specimens and photographs are preserved at NU.

Most of the population sampling was done in Natal, because field work in the Cape, Transvaal and Swaziland was of necessity limited.

Some of this variation can be attributed to response of the individual to fluctuations in water supply inherent in the habitats favoured by *Streptocarpus.* Water scarcity during growth results in smaller leaves and flowers and depauperate inflorescences. This may be seen in plants growing only a foot or so apart when, for various reasons, some are well supplied with water and others are not. Reduction in size under adverse conditions occurs in all species. For this reason, absolute leaf and flower size are misleading diagnostic characters, unless the range of size variation is known and is used in conjunction with other characters.

Apart from size variation, individuals growing together tend to resemble one another closely. Careful investigation will reveal slight differences in shape and depth of colour of corolla lobes, in degree of yellowing in the throat, and in patterning on the limb, but the individuals look similar, and the term "population" is used for such a group.

It is morphological variation *between* populations that can lead to confusion in circumscribing taxa Some species e.g., *S. pentherianus* and *S. gardeni*, both relatively wide-ranging, show very little variation, while others, e.g. *S. haygarthii* N.E.Br. ex C.B.Cl. and *S. cyaneus*, are very variable in size and in colour and markings of their flowers, and also to some extent in shape of corolla lobes. The most reliable taxonomic characters are shape of corolla tube and limb. This is well illustrated in *S. haygarthii* where the shape of the limb remains constant in an otherwise bewildering array of size and colour forms.

Corolla colour in the subgenus ranges from white to violet, except that in *S. dunnii* it is red, while pinkish tones are usual in some populations of *S. cyaneus*, *S. grandis* N.E.Br. and *S. galpini*, and occasional in other species. Albinism is occasional. Corolla colour and markings can be of use in delimiting species, usually only if used in conjunction with other characters.

The filament sometimes has an appendage at its juncture with the connective. This appendage may be a conspicuous tooth visible to the naked eye, or a small "hump" seen only with the aid of a lens.

Leaf number, indumentum and colour (particularly of the under-surface), the presence or absence of a distinct hypocotyl in the monocarpic species, type of indumentum on various organs, the presence or absence of a palatal beard in the corolla tube, number of flowers per peduncle, point of attachment of the filaments in the corolla tube, the anther appendages described above, and capsule dimensions are all useful characters, although their reliability may vary from species to species.

Fritsch (1893) followed by Clarke (1904), used leaf number to delimit sections of the subgenus, which character was reflected in their epithets *Unifoliati* and *Rosulati.* Burtt (1939) pointed out that there is no hard and fast

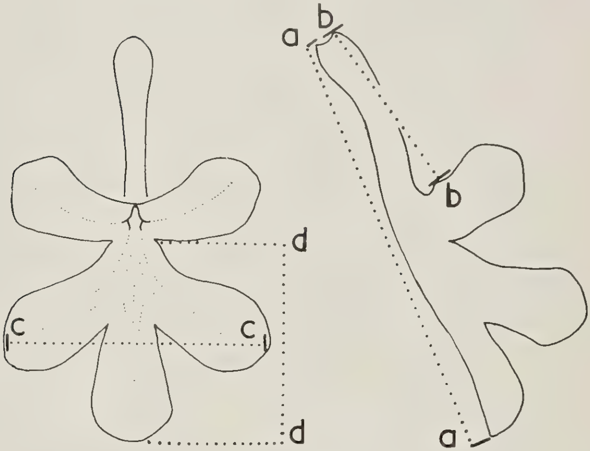


FIG. 2. Diagram of a corolla with "waisted" limb as in *S. haygarthii*. Points of measurement a—a length of flower; b—b length of corolla tube; c—c width of lower lip; d—d length of lower lip.

line between *Unifoliati* and *Rosulati*, and suggested a more satisfactory subdivision could be made if the character of rosulate or unifoliate habit were relegated to a position of secondary importance. This opinion is amply supported by field observations. A much truer picture of the natural affinities of the species is probably obtained by considering corolla shape in conjunction with the ratio of style length to ovary length and the form of style and stigma.

The corolla is bilabiate and the limb may be more conspicuous than the tube or *vice versa*. When the limb is the more conspicuous, the tube is narrow in relation to its length, bent abruptly downward and then projected forward, and is laterally compressed in the mouth (*S. polyanthus* Hook.). When the tube is the more conspicuous, it is generally broad in relation to its length, may be curved (*S. vandeleurii* Bak. f. et S. Moore) or almost straight (*S. fanniniae*) and is always cylindric in the mouth. The tube may, however, be infundibuliform with a conspicuous limb (*S. rexii*).

The style may be longer than, or shorter than, or roughly equal in length to, the ovary. The base of the style tends to persist as an apiculus on the mature capsule. Depending on initial style length and ultimate capsule length, this apiculus may or may not be prominent. It is inconspicuous on both short and long capsules where the style was shorter than the ovary. It is prominent on short capsules where the style was longer than or roughly equal in length to the ovary. There is good correlation between mean pistil length and mean capsule length (Lawrence, 1958). The ratio of style length to ovary length is therefore an indication of ultimate capsule size and the degree of prominence of the persistent style base.

The style may be terete, or dorso-ventrally compressed, or sometimes terete and slightly dorso-ventrally compressed apically. The stigma assumes several different forms. It may be truncate to subcapitate, sometimes jelly-like, sometimes papillose; it may be stomatomorphic and papillose; or be composed of two unequal, reniform papillose lips in the median plane; or of two equal, lingulate, papillose lips held either laterally or in the median plane (Fig. 1). The merit of the stigma as a diagnostic character was arrived at independently of Burtt's (1954) observations on the possible taxonomic value of the stigma in the family as a whole, and lends support to them.

Because there is correlation among them, these gynoecial characters, in conjunction with corolla shape, are used in this series to delimit groups of species.

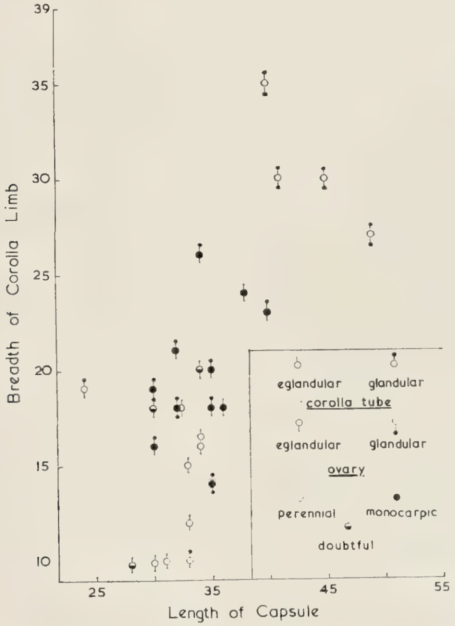


FIG. 3. Pictorialised scatter diagram illustrating continuous variation in breadth of corolla limb, length of capsule, indumentum on corolla tube and ovary, and habit in *S. polyanthus*. (All measurements in mm.)

Species with a narrow corolla tube compressed in the mouth have a terete style much shorter than the ovary, and either a short or long capsule on which the persistent style base is inconspicuous. The stigma may be truncate to subcapitate, sometimes with incipient bilobing, and it is jelly-like or papillose (*S. polyanthus*). The only exception is *S. johannis* in which the stigma is always bilobed and papillose with the lobes held laterally. Lawrence (1958) considered this species, which is aberrant in several other respects, to be of hybrid origin.

In another group, a subcylindric, cylindric or narrowly infundibuliform corolla tube, long in relation to its width, is associated with a terete style, sometimes slightly dorso-ventrally compressed apically, shorter than the ovary, and terminating in a stomatomorphic, papillose stigma. The capsule is long and the persistent style base is inconspicuous (*S. grandis*).

In a third group, the tube may be cylindric to almost campanulate, straight or bent, broad or narrow in relation to its length, the style terete, equalling the ovary in length, and terminated by a stomatomorphic, papillose stigma. The capsule is relatively short and stout with a conspicuous apiculus (*S. cooksonii* B. L. Burtt).

Again, a cylindric, almost straight, relatively small, short and broad corolla tube may be associated with a terete style slightly longer than the ovary and terminated by a stomatomorphic, papillose stigma, sometimes ill-developed and appearing truncate. The capsule is short and stout with a conspicuous apiculus (*S. micranthus* C.B.Cl.).

Finally, the style may be markedly dorso-ventrally compressed, terminating in a stigma composed of two unequal, reniform, papillose lips in the median plane. If the style is shorter than the ovary, it is always associated with an infundibuliform corolla with a conspicuous limb, and the mature capsule is long with an inconspicuous apiculus (*S. rexii*). If the ratio of style length to ovary length is roughly equal, the corolla tube is almost cylindric, straight or slightly curved, relatively short and broad, and the limb generally less conspicuous than the tube. The capsule is relatively short with a prominent apiculus *S. fanniniae*).

In addition to *S. johannis*, there are three other species which do not fit into any of these categories. *S. baudertii* L. L. Britten is morphologically very similar to *S. johannis*, but the stigma lobes are held in the median plane, and the leaves are prostrate rather than erect.

S. dunnii has a subcylindric corolla tube associated with a terete style slightly dorso-ventrally compressed apically, much longer than the ovary and terminated by a papillose, stomatomorphic stigma. The capsule is short and apiculate. *S. pole-evansii* Verdoorn has a cylindric, bent corolla tube associated with a dorso-ventrally compressed and sometimes coiled style, longer than the ovary, and a papillose, stomatomorphic stigma. The capsule is short and apiculate. *S. dunnii*, *S. pole-evansii* and *S. denticulatus* Turrill share the distinction of producing red pigment granules over most of the epidermis.

Fig. 2 illustrates points of measurement and terminology used for the flower. The anther lobe was measured along the line of dehiscence. In most descriptions, limits of capsule length are given, followed in parenthesis by the mean and standard deviation from the mean, based on not less than twenty, generally more than fifty, measurements.

HYBRIDISATION

All the species in subgenus *Streptocarpus* so far investigated (Lawrence et al. 1939) have the same chromosome number and artificial hybridisation has produced the well known fertile garden hybrids. Lawrence (1958) concluded that "the high genic variability that characterises this outbreeding genus . . . is the outcome of a degree of hybridisation", basing his conclusions largely on his own experimental work on the genetics of the genus, because nothing was then known about natural interspecific hybridisation.

Recent field studies have shown that natural interspecific hybridisation is frequent in *Streptocarpus*, yet many species are sympatric but remain distinct. The isolating mechanisms keeping the species separate in nature are obscure, but probably a preference for different habitats is important.

In a stable environment, the delicate balance between well-adapted species and their habitat is maintained, and although crossing may take place, only an occasional inter-specific hybrid survives. Such solitary hybrids are frequently seen in sympatric species populations. But the F_1 hybrids of a cross between species reproductively isolated by only an ecological barrier are fully fertile (Stebbins, 1949). In disturbed habitats, one would therefore expect to find hybrid swarms. Examples of hybridisation associated with human activity are seen particularly where roads have been cut through forest patches on steep terrain, creating rock faces adjacent to forest, and are discussed in relation to *S. haygarthii* in particular.

Hybridisation in *Streptocarpus* is not necessarily a recent phonomenon. There is little doubt that forests were in the past much more extensive in South East Africa than they are at present (cf. Fourcade, 1889). The topography is such that thousands of forest patches survive on escarpments, in the folds of hills, and in kloofs. In some of these occur problematical populations which cannot with certainty be referred to any described species, because, while the individuals closely resemble one another, the population as a whole combines the characteristics of two different species, species not necessarily still growing in the area. These populations are extremely interesting because of their possible hybrid origin. As they exist only as single isolated populations it would serve no useful purpose to give them taxonomic recognition. They are described in the appropriate context as anomalous populations of possible hybrid origin in need of further study and their occurrence has not been permitted to blur the distinctness of the parent species.

THE *S. POLYANTHUS* ALLIANCE

S. polyanthus and its allies form a morphologically distinct group delimited by certain correlated diagnostic criteria. The corolla tube is narrowly cylindric, bent abrubtly downward and then projected forward, and is laterally compressed in the mouth. The flat, oblique limb, more conspicuous than the tube, gives a distinctive facies to the group as a whole. The terete style is shorter than the ovary and is terminated by a truncate to subcapitate or conical stigma, sometimes with incipient bilobing, translucent and jelly-like, or papillose.

Although the alliance is readily diagnosed, its species are perhaps the most intractable, taxonomically, within the whole subgenus, owing to pronounced variation within and, in particular, between populations.

Seven species including four subspecies constitute the *S. polyanthus* alliance, of which two species and two subspecies are here described as new. *S. daviesii*, *S. pentherianus*, *S. silvaticus* and *S. polyanthus* sspp. *comptonii*, *verecundus* and *dracomontanus* show relatively little variation, *S. polyanthus* ssp. *polyanthus* and *S. prolixus* show some variation, *S. confusus* and particularly *S. haygarthii* are extremely variable. Variation is discussed after the description of each species.

The centre of distribution of the group is Natal, which is not a geographically circumscribed area. Although some species have a very limited distribution within the province, others extend southwards into the eastern Cape and northwards into Swaziland and the eastern Transvaal. At least one Tropical African species, *S. compressus* from Tanganyika, has a compressed throat, but may not be closely allied to this group. Distribution is indicated after each species description, together with maps.

General Characteristics of *S. polyanthus* Alliance

Stemless herbs, monocarpic or perennial, terrestrial or epiphytic. *Leaves* 1—5, pilose, base cordate, apex usually withered, margin crenate, upper surface rugulose, veins impressed, veins prominent below. *Inflorescences* several in succession usually from upper surface near base of midrib, cymose. *Calyx* 5-partite, (campanulate and 5-lobed in *S. daviesii*). *Corolla* bilabiate, *tube narrowly subcylindric, bent sharply downwards, then projected forwards,* narrowing towards middle, widening slightly at mouth, *mouth laterally compressed*, base bulbous; limb ± oblique, more conspicuous than tube; upper lip 2-lobed, lower 3-lobed. Fertile *Stamens* 2, epipetalous, inserted halfway up corolla tube; anthers introrse, applanate; staminodes 3. *Disc* annular. *Ovary* terete; *style terete, shorter than ovary*, pubescent; *stigma truncate to subcapitate or conical, translucent, occasionally papillose*. *Capsule* of 2 spirally twisted valves.

KEY TO SPECIES

1a. Calyx campanulate, lobes deltoid — (4) *S. daviesii*
1b. Calyx 5-partite, lobes linear to lanceolate — 2.
2a. Plant with one leaf only; capsule usually 45—90 mm. long — 3.
2b. Plant with two or more leaves; if one leaf only, capsule less than 45 mm. long. — 4.
3a. Primary peduncle originating from upper surface of leaf at base of midrib; corolla limb roundish to elongate, "waisted"; if "waist" obscure, mouth of corolla tube and point of divergence of two upper lobes not contiguous. — (7) *S. haygarthii*
3b. Primary peduncle often originating from apex of hypocotyl and curling up through leaf sinus; corolla limb oblong, not "waisted"; mouth of corolla tube and point of divergence of two upper lobes always contiguous. — (6) *S. confuses*
4a. Corolla always under 20 mm. long, ovary 2 mm., capsule up to 20 mm., often shorter than pedicel. — (5) *S. pentherianus*
4b. Corolla usually over 20 mm. long, ovary at least 3 mm., capsule generally longer than 20 mm., always longer than pedicel unless the stigma is conical. — 5.
5a. Stigma conical, pedicel sometimes longer than capsule, plants epiphytic or on rocks in forest. — (3) *S. silvaticus*
5b. Stigma subcapitate to truncate, sometimes obscurely bilobed, but never conical; plants in crevices of cliffs or rock outcrops, sometimes on cliffs at upper limits of escarpment forest. — 6.
6a. Limb slightly "waisted", capsule c. 1.5 mm. in diameter. — (2) *S. prolixus*
6b. Limb rounded, capsule 2—2.5 mm. in diameter — (1) *S. polyanthus*

ALTERNATIVE KEY TO SPECIES AND ANOMALOUS POPULATIONS

1a. Calyx campanulate, lobes deltoid. — (4) *S. daviesii*
1b. Calyx 5-partite, lobes linear to lanceolate. — 2.
2a. Stigma conical. — 3.
2b. Stigma subcapitate to truncate, sometimes obscurely bilobed, but never conical. — 4.
3a. Leaves several, inflorescence up to 10-flowered. — (3) *S. silvaticus*
3b. Leaf one, inflorescence many-flowered. — (7) Anomalous population "The Start"
4a. Leaf one; capsule usually 45—90 mm. long. — 5.
4b. Leaves two or more; if one only, capsule less than 45 mm. long. — 6.
5a. Primary peduncle originating from upper surface of leaf at base of midrib; corolla limb roundish to elongate, "waisted"; if waist obscure, mouth of corolla tube and point of divergence of two upper lobes not contiguous. — (7) *S. haygarthii*

5b.	Primary peduncle often originating from apex of hypocotyl and curling up through leaf sinus; corolla limb oblong, not "waisted"; mouth of corolla tube and point of divergence of two upper lobes always contiguous.	(6) *S. confusus*
6a.	Corolla always under 20 mm. long, ovary 2 mm., capsule up to 20 mm., often shorter than pedicel.	(5) *S. pentherianus*
6b.	Corolla usually over 20 mm. long, ovary at least 3 mm., capsule generally over 20 mm., always longer than pedicel	7.
7a.	Limb rounded; capsule 2—2.5 mm. in diameter.	(1) *S. polyanthus*
7b.	Limb rounded or "waisted"; capsule c. 1.5 mm. in diameter.	8.
8a.	Limb rounded; leaves subequal in length, suberect.	(2) Anomalous population Kingscliffe
8b.	Limb slightly "waisted"; accessory leaves generally appreciably smaller than flowering leaf, leaves prostrate.	(2) *S. prolixus*

INDEX TO MAIN REFERENCES TO SPECIES, HYBRIDS AND EXAMPLES OF POSSIBLE HYBRID INFLUENCE

(*Synonyms in italics*)

PAGE
angustilobus 34
baudertii 8
comptonii 17
confusus 30
confusus × grandis 34
confusus × haygarthii .. 34, 39
confusus × polyanthus 39
cooksonii 8
cyaneus 3, 5
daviesii 25
daviesii × haygarthii 27
davyi 4
denticulatus 8
dunnii 4, 5, 8
fanniniae 6, 8
galpini 4, 5
gracilis 20
grandis 5, 7
grandis × confusus 34
haygarthii 34
haygarthii × confusus .. 34, 39
haygarthii × daviesii 27
haygarthii × polyanthus 20, 37, 38, 40

PAGE
johannis 7, 8
micranthus 8
pentherianus 21, 27
pole-evansii 8
polyanthus 6, 7, 14, 17
polyanthus ssp. comptonii .. 17, 18
polyanthus ssp. dracomontanus 16, 18
polyanthus ssp. polyanthus .. 14, 18
polyanthus ssp. verecundus .. 15, 18
polyanthus × confusus 39
polyanthus × haygarthii 20, 37, 38, 40
polyanthus × prolixus 19
(polyanthus × prolixus) 22
(polyanthus × silvaticus)
primulifolius 3
prolixus 20, 25
prolixus × polyanthus 19
pusillus 4
rexii 3, 6, 8
reynoldsii 34
silvaticus 23
vandeleurii 6

1. *Streptocarpus polyanthus* Hook. in Bot. Mag. t. 4850 (1855)*, Bot. Mag. t. 4850, of which no specimen was preserved, HOLOTYPE.

Leaves 1—3, prostrate, up to 240 × 170 mm., upper surface light green, sometimes grey-green, lower paler, sometimes suffused reddish-purple particularly on veins. *Inflorescence* up to 36 flowers, few open simultaneously. *Peduncle* up to 250 mm. long, often much shorter, greenish-brown, pilose with glandular and eglandular hairs, glands sometimes absent. *Bracts* linear, up to 3 mm. long, green, pilose. *Flower* 18—45 mm. long. *Pedicel* c. 10 mm. long, elongating in fruit, green, pilose with glandular and eglandular hairs, or glands sometimes absent. *Calyx* 5-partite, lobes linear-lanceolate, 2·5—5 × 0·5—1 mm., green to brown, pilose with glandular and eglandular hairs, glands sometimes absent. *Corolla* tube 10—15 mm. long, greenish-white or

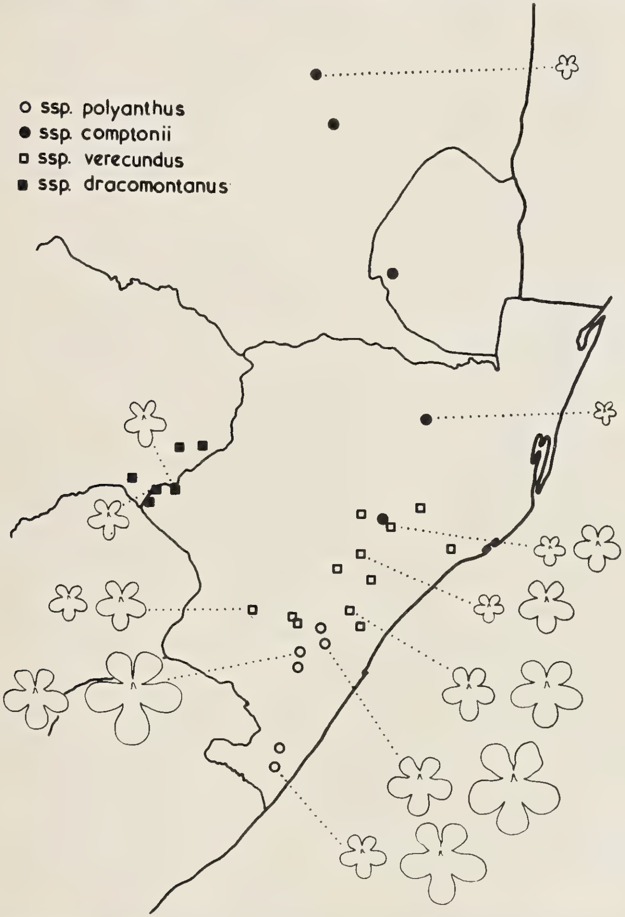


FIG. 4. Pictorialised distribution map of *S. polyanthus* showing similarity in limb shape, but variation in limb size, in the four subspecies. Single diagrams were drawn from herbarium material, pairs of diagrams illustrate size extremes in sampled populations (c. × ½).

very pale violet or whitish abaxially, suffused pale violet adaxially, glandular-pilose, pilose with glandular and eglandular hairs or pilose, base 3—4 mm. in diam.; limb rounded; upper lobes divergent, elliptic-oblong to orbicular, 3—15 × 2·5—12 mm.; lower lip 7—25 mm. long, lobes elliptic to orbicular, 4—17 × 2·5—14 mm.; all lobes pale to medium violet, glandular-pubescent inside, whitish, glandular-pubescent or pubescent outside; throat whitish, greenish-yellow or yellow. *Stamens:* filaments 2·5—4 mm. long, white, curved, curve slightly dilated, glandular or pubescent; anther lobes 1 mm. long, white or violet; posterior staminode minute, laterals 1—1·5 mm. long, white or violet. *Ovary* 4—7 mm. long, green, glandular or pubescent; style c. 2 mm. long, pubescent; stigma truncate to subcapitate. *Capsule* 16—65 mm. long, 2—2·5mm. in diam.

Flowering period: July to February.

ssp. *polyanthus*, *Streptocarpus polyanthus* Hook. in Bot. Mag. t. 4850 (1855)*; Regel, Gartenf. **6** : 297, t. 206 (1857); Crocker in Journ. Linn. Soc. **5** : 65, t. 4, figs. 1—8 (1860); Rev. Hort. 1862 : 250,* 1889 : 398*, 1896 : 12;* Hielscher in Cohn, Beitr. **3** : 1—24, tt. 1—3 (1883); C.B.Cl. in DC. Monog. Phan. **5** : 149 (1883) et in Dyer Fl. Cap. **4** (2) : 440 (1904); Nichols. Dict. Gard. **3** : 516 (1887); Tracy Hubbard in Bailey, Std. Cyclopedia Hort. **3** : 3274 (1937); Burtt in R.H.S. Dict. Gard. ed. **2, 4** : 2045 (1956).

Bot. Mag. t. 4850, HOLOTYPE.

Plant perennial, robust; *leaves* 2 or 3, usually large and thick; *inflorescence* with stout peduncles and often many-flowered; *corolla* limb usually 25 mm. or more broad, lobes thick-textured, the two upper lobes strongly reflexed against the tube, uniform pale violet, white at base of lower lip, yellow in throat; *ovary* glandular-pubescent; *capsule* generally between 36 and 48 mm. long.

NATAL: **New Hanover distr.,** hills east of Nagle Dam, *Story* 6008, PRE. **Pietermaritzburg distr.,** Table Mt., c. 975 m., legit *Downing*, *Hilliard* 1821, NU; nr. Thornville, Farm "Lynmouth", *Hilliard* 2881, NU, E, K. **Richmond distr.,** Sand river, on cliffs, 792 m., *Hilliard* 803, NU. **Camperdown distr.,** Intshanga (Inchanga) 610 m., *Wood* 4824, K, NH; Inchanga, *Forbes* 612, NH; Umgeni valley, *Forbes* 1250, NH; Drummond, 457 m., *Lawson* 161, NU; Inchanga, *Wood* 6616, BM, K, PRE; near Inchanga, *Eshuis* 11306, PRE; Drummond, *Galpin* 9462, K, PRE; Inchanga, *Marloth* 4278, PRE; Inchanga, 671 m., *Hilliard* 801, NU; Umgeni valley, Botha's Hill area, 457 m., *Hilliard* 802, NU; Inchanga, *Stohr* N 15, BM; Inchanga, *Thorns* 289/45 NBG. **Port Shepstone distr.,** Oribi Gorge, 366 m., *Hilliard* 925, E, NH, NU; on St. Faith's road nr. Port Shepstone, 259 m., *Acocks & Hapfström* 1382, K.

spp. *verecundus* Hilliard ssp. nov. a ssp. *polyantho* discreta folio singulo, flore saepe multo minore et capsulae brevitate.

NATAL: **New Hanover distr.** boundary, Noodsberg, Kingscliffe, *Hilliard* 2064, NU, HOLOTYPE, E, K, PRE, ISOTYPES.
Plant usually monocarpic, sometimes doubtfully perennial; *leaf* 1, with a second leaf occasionally developing; *inflorescence* slender, usually less than 12-flowered; *corolla* limb usually less than 26 mm. broad, upper lobes not strongly reflexed, uniform pale violet, yellow in throat; *ovary* pubescent, generally eglandular; *capsule* generally between 29 and 39 mm. long.

NATAL: **Nkandla dist.,** edge of Nkandla Forest below Isibundini Store, 1036 m., *Hilliard* 1169, NU; Qudeni, Mfongozi river, 914 m., *Hilliard* 1922, NU; nr. Dlolwana Store, 823 m., *Hilliard* 2669, NU; Nkandla Forest, Isibundini, 1067 m., *Hilliard* 2671, NU. **Ntonjaneni dist.,** Melmoth, *v/d Merwe* 2448 PRE. **Umvoti dist.,** Rietvlei, Greenwich Farm legit. *Fry* sn. in herb. *Galpin* 2728, K, PRE; Farm "Mowbray", 1097 m., *Hilliard* 1209, NU. **Kranskop dist.,** Ntunjambili Mt., *West* 29186, PRE; Kranskop, 1219 m., *Thode* 3986, STE; forest patch on Kranskop-Middledrift road, *Hilliard* 2562, NU, K. **Mtunzini dist.,** Ngoye Forest, on granite domes, c. 290 m., *Hilliard* 2706, NU. **Lions River dist.,** Dargle, "The Dargle", 1554 m., *Hilliard* 1204, 1215, NU; Hilton College Estate, "The Pinnacle", 1006 m., *Hilliard* 2100, NU. **Mapumulo dist.,** near Fort Cross, c. 7 mls. Mapumulo on road to Kranskop, 1050 m., *Hilliard* 1002, NU. **Pietermaritzburg dist.,** Pietermaritzburg, in natural bush, *Gower* 13, NU. **Ndwedwe dist.,** c. 1 ml. Ndwedwe village, 685 m., *Hilliard* 1004, NU; Inanda Mt., c. 550 m., *Hilliard* 2129, 2039, NU, NH.

spp. *dracomontanus* Hilliard ssp. nov. a ssp. *polyantho* flore saepe multo minore et capsulae brevitate, a ssp. *verecundo* foliis pluribus discreta.

NATAL: **Bergville dist.,** Sungabala Pass, near "The Cavern", 1752 m., *Hilliard* 868, NU, HOLOTYPE.

Plant perennial; *leaves* 2 or 3; *inflorescence* short and relatively stout, generally few-flowered; *corolla* limb generally less than 20 mm. broad, upper lobes not strongly reflexed, uniform pale violet, yellow in throat; *ovary* pubescent, eglandular; *capsule* generally between 23 and 35 mm. long.

NATAL: **Bergville dist.,** Oliviershoek Pass, 1676 m., *Hilliard* 869, NU; farm "The Cavern", *Hodson* 33, NU; Oliviershoek Pass, c. 1800 m., *Thode* 4341, STE; Natal National Park, Plowmans Kop, *Acocks and Hapfström* 1381, PRE; National Park, Tugela Gorge, *Galpin* 10178, PRE.

ORANGE FREE STATE: **Harrismith dist.,** farm "Nelson's Kop", 1920 m., *Hilliard* 1214, NU; Witzieshoek, c. 1800 m., *Thode* 5647, STE; Harrismith, *Sankey* 218, K; Platberg, c. 1980 m., *Putrill* sn, PRE.

ssp. *comptonii* (Mansfeld) Hilliard, stat. et comb. nov. Cult. hort. Bot. Freiburg i Br. (1937), mis. *R. H. Compton*, Kirstenbosch, C.P. HOLOTYPE. *S. comptonii* Mansfeld apud Oehlkers in Zeitschrift für Botanik 32 : 327 (1938);

Burtt in Kew Bull. 1939 : 70 and in R.H.S. Dict. Gard. ed. 2, **4** : 2044 (1956).

Plant apparently monocarpic or perennial; *leaves* 1 or 2, small; *inflorescence* very slender, lax, up to 16-flowered; *corolla* limb generally less than 10 mm. broad, upper lobes not strongly reflexed, uniform pale violet, yellow in throat; *ovary* pubescent, generally eglandular, capsule generally between 29 and 37 mm. long.

TRANSVAAL: **Belfast dist.,** Dullstroom, Steenkampsbergen, 2134 m, *Galpin* 13020, PRE. **Carolina dist.,** Waterval Boven, *Gouws* sn. PRE.

SWAZILAND: **Mankaiana dist.,** nr. Sicanusa, 1219 m., *Compton* 27708, SGH.

NATAL: **Ngotshe dist.,** Ngome forest, around Tendeka rock, *Gerstner* 5169, PRE. **Nkandla dist.,** Nkandla forest, Nomangci rock outcrop, 1280 m., *Hilliard* 1200, NU; 8 miles s. Nkandla on road to Eshowe, *Codd* 9682, PRE.

Hooker described *S. polyanthus* from seedlings that appeared in a basket of living ferns brought to Kew from Natal in 1853. In his description he noted "a dried specimen of the same plant, and from the same country, we possess in our Herbarium, from our friend Mr. Sanderson; and it is, in all probability, the '*Didymocarpus*?' thus mentioned in Krauss, 'Natal Flora', p. 122, 'e summis montibus inter Maritzburg et Natalbay, alt. 2000—3000' ".

Clarke (1883) redescribed the species, and cited *Sanderson* sn. K, *Robinson* sn, K, and *Gueinzius* 220, herb. Wien. Robinson's and Gueinzius' specimens have not been seen, but *Sanderson* sn. TCD, from "rocks above Sterkspruit" is *S. polyanthus*. This is probably a duplicate of the Kew specimen.

Clarke (1904) cited *Sanderson* 511, K, *Fry* 2728, K, *Wood* 4824 and 6616, K, *Gerrard* 2055 (doubtful *sic*) K, TCD. *Sanderson* 511 is *S. prolixus*, *Fry* 2728 is *S. polyanthus* ssp. *verecundus*, *Gerrard* 2055 is *S. cooksonii*, *Wood* 4824 and 6616 are *S. polyanthus* ssp. *polyanthus*. Wood collected his specimens at Inchanga which is very probably the mountain between Maritzburg and Durban (Natal Bay) mentioned by Krauss. The old wagon road between these towns runs just below the cliffs at the summit of Inchanga Hill, which support a large population of *S. polyanthus* ssp. *polyanthus*.

S. comptonii was described from plants raised from seed sent to Germany from Kirstenbosch, the seed having been collected originally by Galpin in the Steenkampsbergen, Transvaal. I have not seen the type, but have examined specimens raised from the original seed sent simultansously to Germany and to the John Innes Horticultural Institute (cult. Trop. Dept., Kew. 11. iv. 1938).

S. comptonii differs from *S. polyanthus* in little other than degree of robustness, flower size and indumentum on the ovary. Relatively little is known about this taxon, which has seldom been collected. All known localities are on quartzitic rock. This somewhat unfavourable habitat could conceivably have resulted in genetically fixed diminutiveness, expressed particularly in flower size.

S. polyanthus ssp. *verecundus* is distinguished from typical *S. polyanthus* largely by its generally solitary-leaved condition and smaller flowers. *S. polyanthus* ssp. *dracomontanus* is virtually indistinguishable from ssp. *verecundus* except by its definitely perennial habit, substantiated by the presence, noticeable even in herbarium material, of old fruiting peduncles in association with new growth.

There is no clearcut discontinuity either in corolla or capsule size in the four taxa. Fig. 3 is a pictorialised scatter diagram correlating breadth of corolla limb and length of capsule, with symbols indicating presence or absence of gland-tipped hairs on corolla tube and ovary, and habit, i.e. monocarpic (one leaf), perennial (several leaves) or doubtful (where some specimens in a

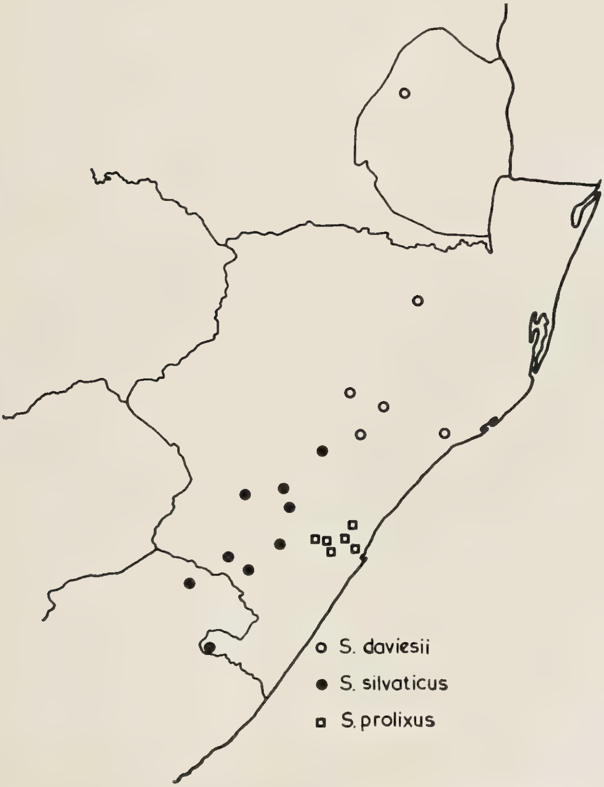


Fig. 5. Distribution map of *S. prolixus*, *S. daviesii* and *S. silvaticus*.

population have more than one leaf, but no remains of old leaves and peduncles). The majority of measurements were made from dried specimens at NU.

All four taxa occupy different geographic areas and are therefore accorded subspecific rank. (Fig. 4). Ssp. *polyanthus* apparently has a limited distribution range in Natal from Table Mountain near Pietermaritzburg southwards to the Port Shepstone area, always at altitudes less than 760 m; ssp. *verecundus* extends roughly from Pietermaritzburg northwards to Melmoth at altitudes from 300 m. to 1500 m; ssp. *comptonii* is known to occur at Nkandla and Ngome in Natal, near Sicanusa in Swaziland, and Waterval Boven and the Steenkampsbergen in the eastern Transvaal, all at altitudes greater than 1200 m.; ssp. *dracomontanus* is apparently confined to the Drakenberg area of Natal and the Orange Free State, also at altitudes greater than 1200 m.

Habitat preference of *S. polyanthus* is generally for rock outcrops on hillsides or krantzes above streams and rivers. The populations are usually on andstone, occasionally on granite, while ssp. *comptonii* is apparently always on quartzites. Ssp. *verecundus* is occasionally found on rocky terrain at the upper limits of escarpment forest, and ssp. *dracomontanus* habitually occupies mossy sandstone boulders in the well-illuminated parts of kloof forest.

Although *S. polyanthus* shows considerable variation in habit and in corolla size, it is nevertheless very easily recognised. The leaves are appressed-pilose. In living specimens, this often gives a grey-green cast to the leaves, which dry silky-silvery. The corolla limb is distinctive in that it is roundish (i.e. there is no well developed sinus between upper and lower lips. (See Fig. 4)). The thick-textured lobes are always uniform pale to medium violet, often with a yellow throat blotch, but no other markings. The capsule is relatively short and stout.

It is suspected that interspecific gene flow can sometimes blur these distinctions. *S. polyanthus* ssp. *polyanthus* and *S. prolixus* are virtually allopatric, but their distribution ranges overlap in the Hillcrest-Botha's Hill area inland from Durban. Here, populations of *S. polyanthus* ssp. *polyanthus* show, presumably, *S. prolixus* influence in their lax inflorescences and slender capsules, but the foliage and corolla shape and texture is typically *S. polyanthus*. In Oribi Gorge near Port Shepstone, large populations of *S. polyanthus* ssp. *polyanthus* grow on the sandstone cliffs above the Umzimkulu and Umzimkulwana rivers and on suitable roadside banks in the gorges themselves. These populations, too, are somewhat atypical in that the flowers are generally smaller, the inflorescences more slender and laxer and the capsules less stout than in typical *S. polyanthus*. *S. haygarthii* and *S. polyanthus* are sympatric here, and it is possible that there is some hybrid influence in the constitution of these populations.

2. *S. prolixus* C.B.Cl. in DC. Monog. Phan. **5** : 151 (1883) and in Dyer, Fl. Cap. **4** (2) : 446 (1904). Natal, Inanda, *Wood* 859, K, HOLOTYPE, NH, ISOTYPE. *S. gracilis* Burtt in Kew Bull. 1937 : 514 and in R.H.S. Dict. Gard. ed. 2, **4** : 2044 (1956). Spec. hort. Bot. Reg. Kew, K, HOLOTYPE.

Perennial. *Leaves* 2 or 3, prostrate, up to 230 × 150 mm., upper surface dark green, lower paler, often suffused purplish-red. *Inflorescence* up to 36 flowers. *Peduncle* up to 200 mm. long, brown to green, pilose with glandular and eglandular hairs. *Bracts* linear, up to 3 × 1 mm., green, pilose. *Flower* c. 27 mm. long. *Pedicel* 9 mm. long, elongating considerably in fruit, green, pilose with glandular and eglandular hairs. *Calyx* 5-partite, lobes linear, 3 × 1 mm., brownish-green, pilose with glandular and eglandular hairs. *Corolla* tube c. 13 mm. long, very pale violet adaxially, white abaxially, glandular-pilose, base 3 mm. in diam.; limb slightly "waisted"; upper lobes divergent, oblong to obovate, 7—11 × 5—6 mm.; lower lip 12—18 mm. long, marked with impressed lines, lobes oblong or oblong-ovate, 6—10 × 4—8 mm.; all lobes very pale violet, glandular inside, paler, sparsely glandular outside; throat yellow. *Stamens:* filaments 2 mm. long, slightly curved, sparsely glandular; anther lobes 1 mm. long, white; posterior staminode minute, laterals 1 mm. long, white. *Ovary* 5 mm. long, greenish-brown, appressed pubescent; style 1·5 mm. long, pubescent, sparsely glandular; stigma subcapitate, translucent. *Capsule* 18—48 (33 ± 5) mm. long, 1·5 mm. in diam.

Flowering period: Oct. to Dec.

NATAL: **Ndwedwe dist.,** Inanda Mt., 600 m., *Hilliard* 2040, NU; **Inanda dist.,** Inanda, Groeneberg, 487 m., *Johnson* 1310, NH, PRE, —do— *Shepherd* 152, NH, —do—, 427 m., *Hilliard* 804, E, NU, K, 808, NU; Inanda Falls, 610 m., *Schelpe* 2964, BM; Kronsberg (Umgeni) (sic, probably Groeneberg) c. 760 m., *Thode* 5282, STE. **Camperdown dist.,** near Shongweni Falls, *Schelpe* 83, NU; Botha's Hill area, Valley of a Thousand Hills, 579 m., *Hilliard* 806, E, NU, NH; Farm "Waterfall", 549 m., *Hilliard* 2139, E, NH, NU; Botha's Hill, Kearsney College, 610 m., *Hilliard* 2809, NU; Cato Ridge, *Fairall* 107, NBG. **Pinetown dist.,** Fields Hill, 366 m., *Sanderson* 511, K, TCD; near Palmiet, *Evans* 142, NH; Everton, Eskotene, 610 m., *Hilliard* 871, NU; Westville, near Durban, Palmiet River, 107 m., *Hilliard* 823, E, K, NH, PRE, NU; Forest Hills, Kloof, 610 m., *Hilliard* 805, NU; Delville Wood, 427 m., *Hilliard* 822, NU. **Umlazi dist.,** Umlazi, sine nomen, sine numero, NH. **Near Durban,** *Wood* 10998, NH; *Britten* sn. PRE; *Hallack* 3, TCD.

S. prolixus is closely allied to *S. polyanthus* from which it is primarily distinguished by its differently shaped corolla limb and by its more slender capsules.

In its type locality, *S. prolixus* is found in myriads in rock crevices at the upper limits of escarpment forest on the Groeneberg, Inanda, and Inanda

Mountain. Numerous populations occur along the lips of kloofs in the shelter of streambank forest in the Kloof and Everton areas, Pinetown district. Burtt (1937) described *S. gracilis* from plants raised from seed from Kloof, but the Kloof and Inanda populations are indistinguishable.

Flower colour is very variable. The populations at Inanda range from almost white to medium violet, with a yellow throat blotch of corresponding intensity. Those from Kloof and Everton are mostly medium violet with a pronounced yellow blotch, and of two known populations near Botha's Hill, one has very pale violet flowers, the other small pure white flowers, both with pale yellow blotches.

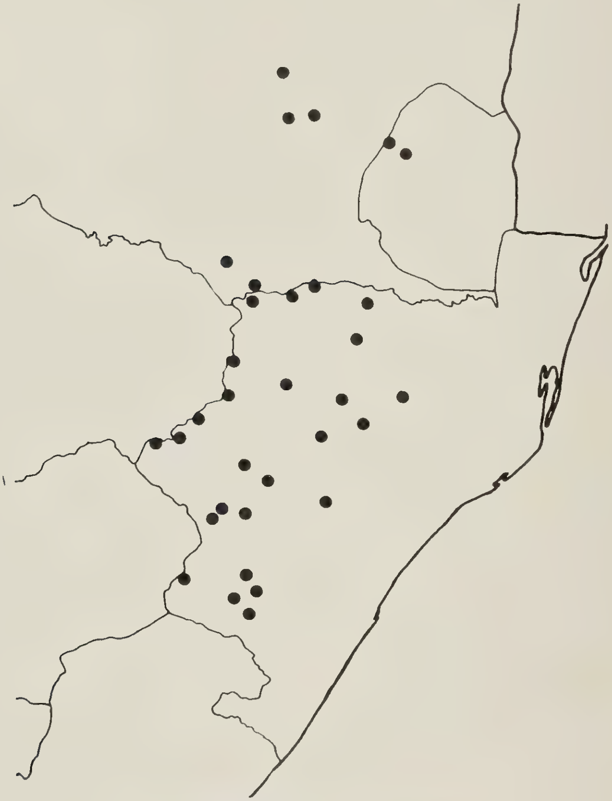


FIG. 6. Distribution map of *S. pentherianus*.

One of these Botha's Hill populations (*Hilliard* 2809) is interesting in that its small white flowers closely resemble those of *S. pentherianus*. The population too is on krantzes in grassveld, the habitat mostly favoured by *S. pentherianus* but not generally by *S. prolixus*. It is tempting to attribute this to possible ancient hybrid influence on the premise that the two species were once in contact, but on the Groeneberg where forest gives way to boulder strewn grassveld, the *S. prolixus* population extends into the grassveld under boulders and the flowers are noticeably smaller and paler than in the main forest population. This Botha's Hill population needs careful analysis before definite conclusions can be drawn.

Beside the road at the summit of the escarpment at Kingscliffe in the Great Noodsberg, a small stream has eroded out a clay seam, leaving a long, narrow cleft in the hillside, partly obscured by streambank forest. The rock walls of this cleft support a large population of *Streptocarpus* which is probably of hybrid origin. (*Hilliard* 884, NU; *West* 2008, PRE.) Individuals appear to be sexually reproductive and the population is morphologically constant, variation being confined to slight differences in corolla size and in shape of corolla lobes.

Anomalous population at Kingscliffe

Perennial. *Leaves* 1—5, suberect, up to 170 × 80 mm., but often much narrower, upper surface dark green, lower purple-red. *Inflorescence* up to 10 flowers, few open simultaneously. *Peduncle* up to 150 mm. long, slender, greenish-brown, sparsely pilose with glandular and eglandular hairs. *Bracts* linear, up to 3 × 0·5 mm., brown, sparsely pilose with glandular and eglandular hairs. *Flower* 28—33 mm. long. *Pedicel* up to 12 mm. long, greenish-brown, sparsely pilose with glandular and eglandular hairs. *Calyx* 5-partite, lobes linear-lanceolate, 3 × 1 mm., brown, sparsely pilose with glandular and eglandular hairs. *Corolla* tube 11—13 mm. long, medium violet adaxially, paler abaxially, pilose with glandular and eglandular hairs, base 2·5—3 mm. in diam., limb more or less rounded; upper lobes divergent, reflexed, elliptic to sub-orbicular, 8—9 × 6—7 mm.; lower lip 13—16 mm. long, lobes elliptic to orbicular, 8—9 × 7—9 mm.; all lobes medium violet, sparsely glandular inside, paler, glabrous outside, white at base of lower lip, yellow blotch in throat. *Stamens:* filaments 4 mm. long, pale violet, curved, sparsely pilose basally, glandular apically; anther lobes 1 mm. long, purplish-violet, darkening at maturity; posterior staminode minute, laterals 2 mm. long. *Ovary* 4—5 mm. long, green, pubescent; style c. 2 mm. long, pubescent; stigma truncate to subcapitate. *Capsule* 25—30 mm. long, 1·5 mm. in diam.

The population appears to be morphologically intermediate between *S. polyanthus* and *S. prolixus* or possibly *S. silvaticus*. The inflorescence is

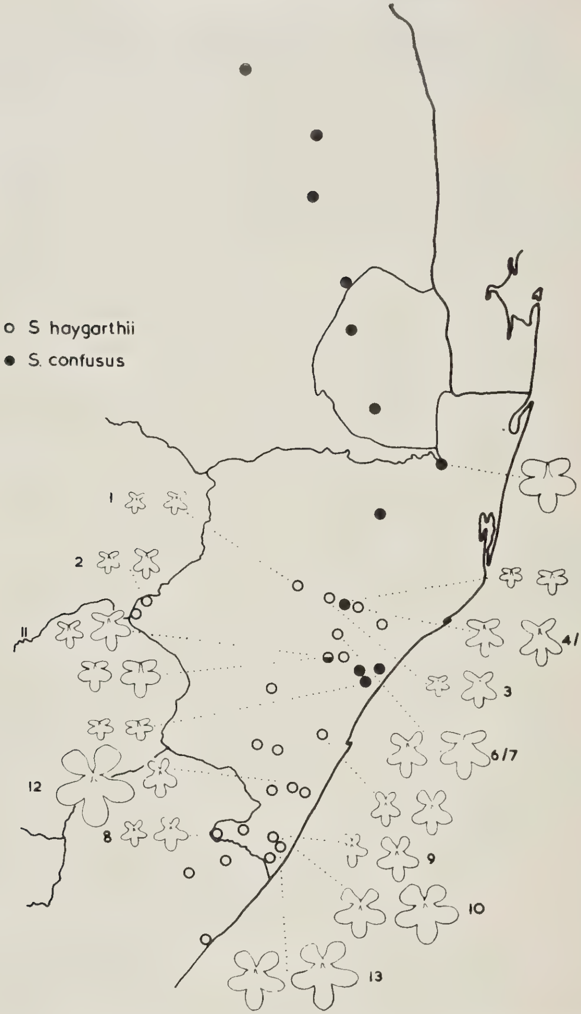


FIG. 7. Pictorialised distribution map of *S. confusus* and *S. haygarthii* showing constancy in limb shape. Size extremes in sampled populations are illustrated (c. × ½) with one corolla (Jozini Dam) from herbarium material.

1. Elandskraal	2. Oliviershoek Pass	3. Qudeni Forest
4. Nkandla Forest (Isibundini)	5. Nkandla Forest	6. Ntunjambili, Kranskop
7. Middledrift rd., Kranskop	8. Mpetyne Forest, Weza	9. Oribi Gorge
10. Oribi Gorge	11. road to Lilani	12. Braemar
	13. Izotsha Falls near Plains	

TABLE I.

To show colour variation in corolla limb in populations of **S. haygarthii,** *numbered as in Fig.* 7.

1. Uniform pale violet.
2. Uniform pinkish-white.
3. White suffused palest violet, usually dark blotch on lower lip.
4. White suffused palest violet.
5. Whitish.
6. Pale to medium violet, dark blotch on lower lip.
7. Pale to medium violet, dark blotch on lower lip.
8. Pure white.
9. White occasionally suffused violet.
10. Pale violet, sometimes yellow in throat.
11. Whitish to very pale violet, sometimes yellow in throat, sometimes violet streaks on lower lip.
12. Pale to medium violet, yellow in throat, dark violet suffusion around mouth.
13. Pale violet suffused deep violet around mouth.

few-flowered as in *S. polyanthus* spp. *verecundus* and *S. silvaticus*. The flowers closely resemble those of *S. polyanthus* in all respects except colour, being darker than *S. polyanthus*, but no darker than some forms of *S. prolixus*. The capsules are similar to those of both *S. prolixus* and *S. silvaticus*, but unlike those of *S. polyanthus*. The leaves of both *S. polyanthus* and *S. prolixus* are thick and stiff and lie more or less flat on the ground. Those of *S. silvaticus* are softer textured and are often suberect. The anomalous population resembles *S. silvaticus* in this respect.

It may be significant that the nearby escarpment edge supports a large population of *S. polyanthus* ssp. *verecundus*. Neither *S. prolixus* nor *S. silvaticus* has been recorded from the area. The Great Noodsberg lies between the territories now occupied by these two species, and either of them might once have occurred in the neighbourhood to hybridise with *S. polyanthus* ssp. *verecundus*.

3. *S. silvaticus* Hilliard sp. nov. *S. prolixo* C.B.Cl. cognatus autem et nonnullis foliis suberectis, et stigmate turbinato et habitu et habitatione distinguitur.

Herba acaulis perennis epiphytica. *Folia* 2—5, ad 120 × 70 mm., pilosa, supra rugulosa, media viriditate, venis impressis, subtus pallidiora, aliquando ianthino suffusa, venis prominentibus. *Inflorescentiae* cymosae, complures ex ordine ab superficie adaxiali prope costae imam partem; flores perpauci, 1 vel 2 simul expansi. *Pendunculus* ad 160 mm. longus, viridis vel purpureo-fuscus, parce pilosus, interdum glaber. *Bracteae* lineares, c. 1·5 mm. longae, virides, pilosae. *Flos* c. 32 mm. longus. *Pedicellus* 8—25 mm. longus, viridis, parce pilosus. *Calyx* quinquepartitus, lobi lineares, 4 × 1 mm., virides, pilosi. *Corolla* bilabiata; tubus 15 mm. longus, viridicans, pubescens, anguste subcylindricus, angulo acuto deflexus, deinde prorsum proiectus, ad medium angustior, paullo latior ad orem, quem a latere compressum est; limbus paullo obliquus, lobi superiores divergentes, oblongi ad suborbiculares, 10 × 7 mm.; labrum inferius 18 mm. longum, carinis duabus parvis sed manifestis ab ima parte lobi anterioris in faucem patentibus, lobi oblongi ad suborbiculares, 12 × 10 mm., lobi omnes purpurei-pallidi, praeter pubertatem glandulosam circum orem glabri; faux fulvo-viridis. *Stamina:* fertilia 2, filamenta 3 mm. longa, curvata, viridi-alba, parce glanduloso-pilosa, ad medium corollae tubum inserta; antherarum lobi confluentes, 1 mm. longi, fulvi; staminodia 3, minima. *Ovarium* 3 mm. longum, viride, subtiliter pubescens; stigma turbinatus, 1 mm. longum, translucens. *Capsula* 17—54 (30 ± 8) mm. longa, 1·5 mm. lata.

NATAL: **Richmond dist.,** farm "Osgodsby", 1142 m., *Hilliard* 811, NU, HOLOTYPE, E, K, PRE, ISOTYPES.

NATAL: **Umvoti dist.,** Greytown, Dam Waterval, *v/d Merwe* 2497, PRE. **Lions River dist.,** farm "The Dargle", 1554 m, *Hilliard* 1211, NU; Karkloof, farm "The Start", 1067 m., *Hilliard* 1000, NU; Dargle, farm "Kilgobbin", 1311 m, *Hilliard* 845, K, E, NH, NU, PRE; Karkloof, Blinkwater Bush, 1524 m, *Hilliard* 2603, NU. **Polela dist.,** Donnybrook, Xumeni Forest, 1372 m, *Hilliard* 2477, NU, PRE. **Pietermaritzburg dist.,** Winterskloof, *F.G.C.* sn, J37540, J. **Richmond dist.,** Byrne Valley, farm "Newborough Grange", 1128 m, *Hilliard* 840, E, NU; Richmond, Byrne, *Galpin* 11979, K, PRE; Richmond, Enon Forest, 1189 m, *Hilliard* 2029, NU. **Ixopo dist.,** Qunu Falls, 1036 m, *Hilliard* 923, E, K, NU. **Alfred dist.,** Weza, Mpetyne Forest, c. 1200 m, *Hilliard* 1923, NU.

CAPE: **Umzimkulu dist.,** Insikeni Forest, 1615 m, *Hilliard* 2486, NU. Perennial. *Leaves* 2—5, suberect, up to 120 × 70 mm., upper surface mid-green, lower paler, occasionally suffused purple. *Inflorescence* flowers few (c. 10), 1 or 2 expanded simultaneously. *Peduncle* up to 160 mm. long, green or purple-brown, sparsely pilose, sometimes glabrous. *Bracts* linear, c. 1·5 mm. long, green, pilose. *Flower* c. 32 mm. long. *Pedicel* 8—25 mm. long, green, sparsely pilose. *Calyx* 5-partite, lobes linear, 4 × 1 mm., green, pilose. *Corolla* tube 15 mm. long, greenish, pubescent, base 2·5 mm. in diam.; upper lobes divergent, oblong to suborbicular, 10 × 7 mm.; lower lip 18 mm. long, with 2 small but distinct keels extending from base of anterior lobe into throat, lobes oblong to suborbicular, 12 × 10 mm., all lobes pale violet, glabrous except for glandular pubescence around mouth; throat yellow-green. *Stamens*: filaments 3 mm. long, curved, greenish-white, sparsely glandular pilose; anther lobes 1 mm. long, yellow; staminodes minute. *Ovary* 3 mm. long, green, minutely pubescent; style 1·5 mm. long, greenish-yellow, minutely pubescent; stigma conical, 1 mm. long, translucent. *Capsule* 17—54 (30 ± 8) mm. long, 1·5 mm. in diam.

Flowering period: Oct. to Jan.

S. silvaticus is extremely common in forests at altitudes greater than 900 m., excluding the Drakensberg forests, and has a known distribution range from the Greytown area, Natal, to East Griqualand (Fig. 5). It is so common that it is amazing it has for so long been overlooked. It shares with *S. daviesii* the distinction of growing only epiphytically or lithophytically, and like that species shows little floral variation. *S. silvaticus* virtually replaces *S. daviesii* in the Mistbelt forests south of the Tugela, and although it could never be mistaken for that distinctive species, floristically they are very similar and have almost identical stigmas.

Herbarium material of *S. prolixus* and *S. silvaticus* can be difficult to distinguish. Both corolla and capsule are very similar, but the stigma of *S. silvaticus* is always conical, whereas that of *S. prolixus* is subcapitate. The two species also differ markedly in habit and habitat. *S. silvaticus* is always epiphytic or lithophytic in Midlands forest at altitudes greater than 900 m. *S. prolixus* is always rooted in soil or wedged in rock crevices at altitudes less than 670 m.

4. *S. daviesii* N.E.Br. ex C.B.Cl. in Dyer, Fl. Cap. **4**(2) : 439 (1904), B. L. Burtt in R.H.S. Dict. Gard. ed. 2, **4** : 2044 (1956). Zululand, Qudeni Forest, 1829 m., *J. M. Wood* 7963 legit *G. W. Davies* 55, K, HOLOTYPE, NH, ISOTYPE.

Perennial. *Leaves* 1 or 2, up to 240 × 175 mm., usually much smaller, often markedly cordate, apex acute, usually unwithered, upper surface pale green, lower paler, occasionally suffused purple, midrib plane. *Inflorescence* flowers several (c. 20), few open simultaneously. *Peduncle* up to 100 mm. long, brown to green, pilose. *Bracts* lanceolate, up to 10 × 2·5 mm., green, pilose.

Flower c. 45 mm. long. *Pedicel* c. 6 mm. long, green, pilose. *Calyx* campanulate, tube 5 mm. long, green, glabrous within, pubescent without; lobes 5, deltoid, 5 × 4·5 mm., green, pubescent without, glabrous within. *Corolla* tube c. 18 mm. long, base 3 mm. in diam., tube widening upwards, strongly compressed laterally in upper half, greenish abaxially, deep violet adaxially, pilose with glandular and eglandular hairs without, pubescent within; upper lobes divergent, suborbicular, 14 × 12 mm.; lower lip 23 mm. long, lobes suborbicular, 13 × 14·5 mm., with 2 raised keels extending from base anterior lobe into throat; all lobes medium violet fading to white in mouth, paler outside, sparsely pilose with glandular and eglandular hairs; yellow blotch in throat. *Stamens:* filaments 2 mm. long with small swelling apically, white, pubescent; anther lobes 1·5 mm. long, apiculate, white; posterior staminode minute, laterals 1 mm. long, white. *Ovary* 5 mm. long, green suffused purple apically, appressed pubescent; style 2·5 mm. long, greenish, pubescent; stigma conical, translucent. *Capsule* 28—53 (40 ± 5) mm. long, 2 mm. in diam.

Flowering period: Dec. to March.

SWAZILAND: **Mbabane dist.,** Black Mbuluzi River Valley, 1173 m., *Hilliard* 3106, NU.

NATAL: **Ngotshe dist.,** Ngome forest, c. 1060 m, *Hilliard* 865, NU. **Nkandla dist.,** Qudeni, *Dyer and Collett* 4703, K, PRE; Qudeni, Codd 9676, PRE; Qudeni, *Fisher and Schweickerdt* 70, NH, NU, PRE; Qudeni, *Gerstner* 665, PRE; Qudeni, *Fisher* 861, NH, NU, PRE; Qudeni, c. 1500 m., *Hilliard* 859, NU; Nkandla, *Smuts*, sn, PRE; do. *Gerstner* 3219, K, PRE; do. *Wylie* in herb. *Wood* 8835, NH; do. *Strey* 4157, NU; do. *Laughton* J 32159, J. **Kranskop dist.,** Ntunjambili Mt., Middledrift road, *West* sn, PRE; road to Middledrift, c. 1060 m., *Hilliard* 1455, NU, 2561, NU. **Mtunzini dist.,** Ngoye Forest, *Huntley* 296, PRE; Ngoye Forest, 274 m., *Hilliard* 2709, NU.

S. daviesii is very readily recognised by its campanulate calyx and its habit of producing only one flowering leaf per season with next year's young leaf superimposed upon it. *S. pentherianus* occasionally develops superimposed leaves, but these are easily distinguished from the light green, cordate leaves of *S. daviesii.* Similarities in corolla and stigma structure suggest close affinity between *S. daviesii* and *S. silvaticus.*

Like *S. silvaticus, S. daviesii* grows epiphytically or on rock faces, and shows very little morphological variation. Throughout Qudeni and Nkandla forests, where it is particularly common, the corolla is medium violet with occasional paler or darker specimens. In the forest patch on the road from Kranskop to

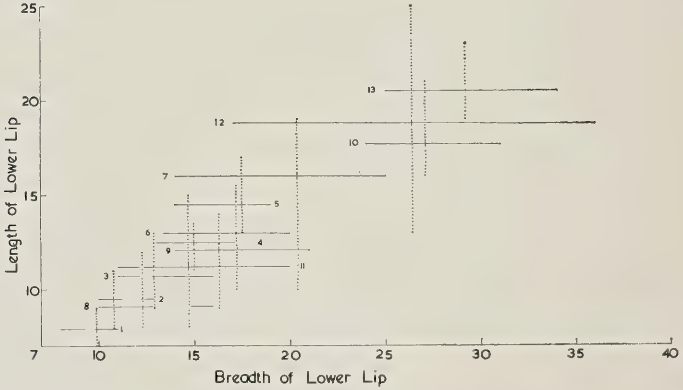


FIG. 8. Pictorial diagram illustrating limits and means of dimensions of lower lip in *S. haygarthii.* (Numbers refer to populations illustrated in Fig. 7.) (All measurements in mm.)

Middledrift, the margins of the corolla lobes have a decidedly pink tinge, and the few specimens (quite the largest yet seen) noted in Ngoye forest were almost pure white.

Until recently, *S. daviesii* was thought to be confined to Qudeni and Nkandla forests and the forest facing them across the Tugela below Kranskop. Field work extended the known range to Ngoye and Ngome forests, but it was a surprise to find extensive populations over a hundred miles north of Ngome on granite boulders in forest patches near Mbabane, Swaziland.

Occasional hybrids between, presumably, *S. daviesii* and *S. haygarthii* have been seen in Qudeni forest and between Kranskop and Middledrift.

5. *S. pentherianus* Fritsch apud Zahlbruckner in Ann. Hofm. Wien **15** : 71 (1900). NATAL: near Colenso, leg. *Krook* (pl. *Penther* 2107), Wien, HOLOTYPE. Perennial. *Leaves* 1 to 3, up to 120 × 84 mm., upper surface dark green, lower paler, occasionally suffused purple. *Inflorescence* few-flowered (c. 12 flowers). *Peduncle* up to 120 mm. long, greenish-brown, pilose with glandular and eglandular hairs. *Bracts* linear, up to 2 × 0·5 mm., green, pilose with glandular and eglandular hairs. *Flower* c. 18 mm. long. *Pedicel* c. 10 mm. long, elongating to 20 mm. in fruit, green, sparsely pilose, glandular. *Calyx* 5-partite, lobes linear, 2 × 0·5 mm., green, pilose with glandular and eglandular hairs. *Corolla* tube 9 mm. long, greenish-white, sometimes suffused medium violet adaxially, pilose with glandular and eglandular hairs; upper lobes divergent, elliptical, 6 × 3 mm.; lower lip 10 mm. long, lobes oblong to suborbicular, c. 6 × 4 mm.; all lobes white, minutely glandular-pubescent inside, pubescent with glandular and eglandular hairs outside, yellow blotch in throat. *Stamens:* filaments 2·5 mm. long, slightly curved, greenish-white, glandular; anther lobes 1 mm. long, purplish; posterior staminode minute, laterals 0·5 mm. long, white. *Ovary* 2 mm. long, green, pubescent, sparsely glandular; style 1 mm. long; stigma truncate to subcapitate. *Capsule* 9—20 (14 ± 2) mm. long, 2 mm. in diam., often deflexed at maturity.

Flowering period: Nov. to March.

TRANSVAAL: **Belfast dist.,** Belfast, *Leendertz* 2679, PRE. **Carolina dist.,** Witkloof, *v/d Merwe* sn, PRE; between Carolina and Badplaats, *v/d Merwe* 2267, PRE; Carolina, *Moss and Rogers* 1141, BM, K, J. **Ermelo dist.,** Roodepoort, 1730 m., *Henrici* 1688, PRE; Nooitgedacht, 1730 m., *Henrici* 237, PRE. **Volksrust dist.,** Volksrust, *Jenkins* 9311, PRE; summit Paardekop range, c. 2200 m., *Galpin* 9856, PRE. **Wakkerstroom dist.,** *van Dam* 24353, PRE; Waterval, *v/d Merwe* 2062, PRE; Mavieriestad, *Pott* 15169, PRE.

SWAZILAND: **Mbabane dist.,** c. 25 mls. W. Mbabane, *Story* 5426, PRE; below farm "Stroma", c. 1200 m., *Hilliard* 3103, NU; c. 7 mls. turnoff to Piggs

Peak from Mbabane-Ermelo rd., c. 1300 m., *Hilliard* 3091, NU; Mbabane, Fonteyn, 1430 m., *Hilliard* 3069, NU; Ngotshane Rocks, c. 1500 m., *Compton* 26789, SGH; Hawane Falls, c. 1300 m., *Compton* 27413, SGH.

BASUTOLAND: without precise locality, *Cooper* 947 in partim, K.

NATAL: **Newcastle dist.,** Coldstream, *Rehmann* 6916, K (cited by Clarke (1904) as *S. pusillus*); Laings Nek, *Marais* 361, K, PRE; Normandien Pass, 1935 m., *Hilliard* 1038, 2376, NU; Drakensberg near Newcastle, *Wilms* 2173, K; Mullers Pass, "Moorfield", 1890 m., *Hilliard* 2340, NU; Farm "Majuba" on Quagga's Nek road, 1829 m., *Hilliard* 2258, NH, NU. **Utrecht dist.,** Pongola Mts. to Kaffir Drift, *Thode* A340, NH, PRE; summit escarpment between Groenvlei and Wakkerstroom, 1950 m, *Hilliard* 2249, E, NU. **Paulpietersburg dist.,** summit Dumbe Mt., *Galpin* 9664, PRE. **Bergville dist.,** Oliviershoek, 15—1800 m., *Thode* 7828, STE; Strydhoek, near Tintwa Mt., *Doidge* sn, PRE. **Klip River dist.,** Van Reenen, 1768 m., *Phillips* sn, PRE; Van Reenen, 15—1800 m., *Wood* 6275, PRE; Van Reenen Pass, 1676 m., *Hilliard* 1034, NU, 1846, E, K, NU; Collings Pass, 1676 m., *Hilliard* 1041, NU. **Dundee dist.,** Hattingspruit, *Scott*, sn, PRE; Dundee, Mpati Mt., *Shirley* sn, NU. **Nqutu dist.,** Nqutu, *Gerstner* 2858, NH. **Vryheid dist.,** Vryheid Mt., *v/d Merwe* 2653, PRE; Inhlasatshe Mt., *Gerstner*, sn, NH; Mt. near turnoff from Vryheid to Natal Spa, 1264 m, *Hilliard* 3116, NU. **Helpmekaar-Msinga dist.** boundary, farm "Elandskraal", 1372 m., *Hilliard* 1819, NU. **Babanango dist.,** 15 mls. N. Qudeni, 1615 m., *Fisher and Schweickerdt* 121, NU, PRE; do., *Hilliard* 827, E, K, NU, NBG. **Estcourt dist.,** Bushmans River valley, c. 1800 m., *Thode* 5551, STE; Giant's Castle Game Reserve, c. 1500 m., *Skead* 145, NU; Lowlands, *Schelpe* 32, NU; Tabamhlope forest, *West* 1419, PRE; 3·7 mls. E. Tabamhlope Police Station, *Marais* 1468, PRE; Tabamhlope Mt., 1890 m., *West* 1358, PRE; 0·2 mls. White Mt. Inn, Hlatikulu, 1585 m., *Killick and Marais* 2166, PRE; Dalton Bridge, 1341 m., *Pentz* 583, K, PRE; do., c. 1200 m, *West* 1359, PRE; Lowlands, 1341 m., *Hilliard* 852, NU; Willowgrange, 1356 m., *Hilliard* 853, E, NU; Tabamhlope Mt., 1707 m., *Hilliard* 1491, NU. **Weenen dist.,** Weenen veld reserve, 1006 m., *Pentz and Acocks* 10728, NH. **Umvoti dist.,** 8 mls. Greytown on Muden rd., *Hilliard* 1231, NU. **Mpendle dist.,** Lundies Hill en route Bulwer, 1264 m., *Hilliard* 817, NU; **Underberg dist.,** Sani Post (*sic* Pass), Webb 133, NU; Sani Pass area, 1600 m., *Hilliard* 954, 1035, NU. **Polela dist.,** Bulwer, Marwaga Mt., *Marais* 1455, PRE; Bulwer, Ngelabantwan River, 1372 m., *Hilliard* 860, NU; Donnybrook, "Meadow Farm", 1280 m., *Hilliard* 2962, NU.

This small species is usually found at altitudes greater than 1200 m., growing in the crevices of rock outcrops with a southerly aspect. In the Drakensberg area it is usually on mossy rocks in forest. It is widely distributed in Natal, Swaziland and the south eastern Transvaal (Fig. 6) and shows no significant variation throughout its range.

S. pentherianus is easily distinguished from all other members of the group by its short capsule. It has been much confused with *S. pusillus* but this is lack of observation of the corolla tube which is narrow, bent, and compressed in the mouth in *S. pentherianus*, relatively broad, almost straight, and cylindric in the mouth in *S. pusillus*. It could conceivably be confused with *S. polyanthus* ssp. *comptonii* but apart from marked differences in the shape and colouring of the corolla limb, the short capsule, generally shorter than the pedicel, is diagnostic of *S. pentherianus*.

6. *S. confusus* Hilliard sp. nov. *S. haygarthii* cognatus, discretus autem corollae limbo longo cujus media pars non contracta est, quae contractio *S. haygarthii* propria est.

Folium 1, ad 300 × 170 mm., supra viridis-nigrum, subtus pallidior rubro-purpura suffusum praecipue in venis lateralibus, interdum glandulosum. *Inflorescentiae* ab hypocotylo et ima parte costae orientes; flores plurimi, pauci eodem tempore expansi. *Pedunculus* ad 300 mm. longus, fuscus vel viridis, pilosus. *Bracteae* lineares, ad 4 × 1 mm., aut fuscae aut virides, pilosae. *Flos* 20—30 mm. longus. *Pedicelli* c. 8 mm. longi, paullo longiores in fructificatione, viridi-fusci, glandulosi, pilosi. *Calycis* lobi lineares, 2·5 × 0·5 mm., virides vel fusci, pilosi. *Corolla* bilabiata; tubus 10—15 mm. longus, adaxiale ianthino-pallidus, abaxiale albus, glanduloso-pilosus, parte inferiore 2·5 mm. lata, fauce a lateribus compressa; limbus fere oblongus, parte media non contracta; lobi superiores divaricati; labrum inferius 8—13 mm. longum, lineis impressis obscure notatum; lobi omnes oblongi ad suborbiculares, 6—7 × 4—7 mm., ianthino-pallida, intus glandulosi, extra pallidiores glanduloso-pilosi; fauces aut albae aut luteae. *Stamina* fertilia 2; filamenta 3 mm. longa, paullo curvata, alba suffusa ianthino-suffusa, parce glandulosa, in medio corollae tubo orientia; antherarum lobi 1 mm. longi, albi; staminodia 3, posteriora admodum minima, lateralia 1 mm. longa. *Ovarium* 6 mm. longum, viride, pubescens; stylus 1 mm. longus, albus, pubescens; stigma capitatum. *Capsula* 42—91 (66 ± 10) mm. longa, 2 mm. lata.

NATAL: **Mapumulo dist.,** tributary Nsuze River, 610 m., *Hilliard* 807, NU, HOLOTYPE; E, PRE, ISOTYPES.

TRANSVAAL: Letaba dist., The Downs, *Story* 5409, PRE; The Downs, S. slopes Mamatseeri Mt., *Burtt* 2912, E, NU, PRE. **Pilgrimsrest dist.,** Mariepskop, *Burtt* 2930, E, NU, PRE; Mariepskop, *Merxmueller* 621, K; Sabie Forest Reserve, Ceylon Section, 1190 m., *Hilliard* 2958, E, NU. **Barberton dist.,** Barytes Mine, Barberton-Havelock rd., *Burtt* 2942, E, NU, PRE. **Dist. unknown,** Umzeila, *Mudd* sn, K.

SWAZILAND: **Hlatikulu dist.,** Hlatikulu, c. 1200 m., *Compton* 27421, SGH.

NATAL: **Ngotshe dist.,** Ngome, forest patch beside road to Nongoma, 930 m., *Hilliard* 872, E, NU, 867, NU, NH; 6 mls. SE Ngome Forest Station, 945 m., *Codd* 9600, PRE; Ngome, *Gerstner* 5169, PRE. **Nkandla dist.,** Nsuze River Valley on Qudeni-Nkandla road, *Burtt* 2970, E. NU. **Umvoti dist.,** near Glenmill, 168 m., *Hilliard* 857, E, NU; near Ahrens, farm "Mowbray", 1067 m., *Hilliard* 1005, E, NU; road to Lilani, *Mrs. H. Alderton* sn, NU; near Lilani, 914 m., *Hilliard* 843, NU, 1956, NH, NU. **Lower Tugela dist.,** near Darnall, Kildare Estate, 168 m., *Hilliard* 926, NU, PRE; 3 mls. Doornkop on Mapumulo Road, c. 600 m., *Hilliard* 2122, NU.

Monocarpic. *Leaf* 1, up to 300 × 170 mm., upper surface dark green, lower paler, suffused purplish-red particularly on lateral veins, sometimes glandular. *Inflorescence* from hypocotyl and base of midrib, flowers numerous, few expanded simultaneously. *Peduncle* up to 300 mm. long, brown to green, pilose. *Bracts* linear, up to 4 × 1 mm., brown or green, pilose. *Flower* 20—30 mm. long. *Pedicel* c. 8 mm. long, elongating slightly in fruit, greenish brown, pilose with glandular and eglandular hairs. *Calyx* lobes linear, 2·5 × 0·5 mm., green to brown, pilose. *Corolla* tube 10—15 mm. long, pale violet adaxially, white abaxially, pilose with glandular and eglandular hairs, base 2·5 mm. in diam; limb more or less oblong, not "waisted", upper lobes divaricate; lower lip 8—13 mm. long, faintly marked with impressed lines; all lobes oblong to suborbicular, 6—7 × 4—7 mm., pale violet, glandular-pubescent inside, paler, pilose with glandular and eglandular hairs outside; throat white or pale yellow. *Stamens:* filaments 3 mm. long, slightly curved, white suffused violet, sparsely glandular; anther lobes 1 mm. long, white; posterior staminode minute, laterals 1 mm. long. *Ovary* 6 mm. long, green, appressed pubescent; style 1 mm. long, white; stigma subcapitate. *Capsule* 42—91 (66 ± 10) mm. long, 2 mm. in diam.

Flowering period: Oct. to March.

S. confusus is found on the walls of kloofs or on steep earth or rock banks, generally in forest, but it seems, at least in Natal, to be far more tolerant of drier and more exposed habitats than *S. haygarthii.* This is well demonstrated along the road to Lilani, near Greytown, the only known locality where the two species grow together. *S. haygarthii* favours moist banks on the forest floor, *S. confusus* drier, shaded banks not necessarily in forest. In Natal populations, the primary peduncle arises from the apex of the hypocotyl and not from the base of the midrib as is usual in this group. The manner in which the peduncle then curls up through the leaf sinus is easily detected even in herbarium material.

S. confusus has a distribution range in eastern Natal from north of Durban through Swaziland to the eastern Transvaal (Fig. 7). In all known Natal populations as far north as Ngome, the primary peduncle develops from the hypocotyl. Hlatikulu forest, Swaziland, supports large populations in which this character can sometimes be detected, but further north at Mbabane, in the forests between Havelock and Barberton, and northwards to Sabie and Mariepskop, it disappears entirely and the primary peduncle develops from the upper surface of the leaf at the base of the midrib. These populations are found in wetter forest habitats than in Natal, so this may be a character developing only under the influence of drier habitat conditions.

The one constant character distinguishing this species from *S. haygarthi* is the shape of the corolla limb. The two upper lobes are markedly divaricate and the two lateral lobes of the lower lip diverge immediately with practically no development of a sinus between upper and lower lips. This distinguishes *S. confusus* from *S. haygarthii* in which a sinus is always developed and the limb can be described as "waisted". In *S. confusus* the mouth of the corolla tube and the point of divergence of the two upper lobes are always contiguous. In those populations of *S. haygarthii* with only slight development of "waisting", the upper lobes are divergent rather than divaricate, and the mouth of the corolla tube is always one or two mm. below the point of divergence (Fig. 7). The two species thus never need be confused, and are easily distinguished from all other members of the group by their solitary leaves and long capsules.

Variation in *S. confusus* is, apart from point of origin of peduncles, largely confined to corolla size and colouring. The majority of populations seen throughout the distribution range have small flowers less than 23 mm. long. Colour ranges from white to pale violet, often with a pale yellow blotch in the throat, but without other markings. Along the Lilani road, however, flowers are larger (28—30 mm. long), deep violet-blue in colour with a bright yellow throat blotch, and the corolla lobes tend to be suborbicular rather than oblong as in all other populations. Several more or less discrete populations can be seen in the local forest patches, and they are morphologically constant. But they differ so strikingly in corolla size, colour, and shape of lobes from all other known populations of the species that it is suspected that they have been contaminated by gene exchange with local populations of *S. polyanthus* ssp. *verecundus*.

S. confusus may hybridise naturally when growing with other species. Hybrids are occasional where *S. confusus* and *S. grandis* are sympatric in the environs of Ngome forest. But where human activity has created disturbed habitats, hybrid swarms have become established. These are discussed under *S. haygarthii.*

An interesting taxon is known to occur in Pongola Poort and other kloofs in the Lebombo mountains (*Ubombo dist.*, Jozini Dam, *Strey* 5311, NH). This taxon has flowers up to 50 mm. long and sometimes develops bilobed stigmas, but otherwise appears to be indistinguishable from typical *S. confusus.* Its taxonomic status cannot be determined until it has been investigated in the field.

7. *S. haygarthii* N.E.Br. ex C.B.Cl. in Dyer, Fl. Cap. **4** (2) : 440 (1904). NATAL: Zululand, Isibundini, *Haygarth* sn. (herb. *Medley Wood* 7465) K, LECTOTYPE. (*Haygarth* sn, NH, is *S. grandis* N.E.Br., the two species having been collected simultaneously by Haygarth, which led C. B. Clarke (1904) to describe the leaf of *S. grandis* as that of *S. haygarthii* (N. E. Brown, 1905)). Clarke (1904) did not designate a holotype, but all his cited specimens have been examined, and all but *Mudd* sn, Umzeila, Transvaal, are *S. haygarthii*).

S. reynoldsii Verdoorn in Fl. Pl. S. Afr. 21, t. 804 (1941)*; B. L. Burtt in R.H.S. Dict. Gard. ed. 2, 4 : 2045 (1956). **Nkandla dist.,** Nkandla, 16 mls. S. of, *Reynolds* 3229, PRE, HOLOTYPE.

S. angustilobus N.E.Br. nomen, J. M. Wood in Trans. S. Afr. Phil. Soc. 18 (2) : 202 (1908), nomen.

Monocarpic. *Leaf* 1, up to 300 × 450 mm., often much smaller, upper surface dark green, lower often purplish-red. *Inflorescence* c. 36-flowered. *Peduncle* up to 365 mm. long, brownish green, sparsely pilose with glandular and eglandular hairs. *Bracts* elliptic to lanceolate, up to 10 × 2 mm., green to brown, pilose. *Flower* up to 45 mm. long. *Pedicel* 10—12 mm. long, elongating in fruit, greenish-brown, pilose with glandular and eglandular hairs. *Calyx* lobes linear to lanceolate, 3 × 1 mm., green to brown, pilose, sometimes with glandular hairs. *Corolla* tube 8—20 mm. long, white to pale violet, glandular-pilose, base c. 3 mm. in diam.; upper lobes divergent to divaricate, oblong to obovate, 8—10 × 4—6 mm. at apex; lower lip 8—29 mm. long, lobes directed downwards and outwards giving a "waisted" effect to the limb, lobes oblong to obovate, 7—9 × 3·5—6 mm.; all lobes white to pale violet, glandular inside, glandular or glabrous outside, lower lip marked with impressed lines, sometimes with violet streaks or blotches; throat white or pale yellow, mouth sometimes suffused violet. *Stamens:* filaments 1·5—3 mm. long, white, sparsely glandular; anther lobes 1 mm. long, white; staminodes minute. *Ovary* 4·5—7 mm. long, green, appressed pubescent; style 1·5—2·5 mm. long, white, pubescent with glandular and eglandular hairs; stigma subcapitate. *Capsule* 25—84 (56 ± 7) mm. long, 1·5 mm. in diam.

Flowering period: Sept. to April.

NATAL: **Bergville dist.,** Oliviershoek Pass, 1676 m., *Hilliard* 851, E, K, NU, PRE; farm "The Cavern", 1219 m., *Hilliard* 850, E, NU; Oliviershoek Pass, c. 1500 m., *Thode* 3984, 3985, STE; Mont Aux Sources, *McLean and Bayer* 128, K. **Helpmekaar dist.,** road to Elandskraal, 1433 m., *Hilliard* 1864, NU. **Nkandla dist.,** Nkandla, 12 mls. S. of, *Reynolds* 3227, PRE; Nkandla forest, 1158 m., *Codd* 6976, PRE; -do- 1219 m., *Hilliard* 829, E, K, NH, NU; -do- Isibundini, 1036 m., *Hilliard* 815, NU; -do- Nomangci, *Hilliard* 816, E, K, NU, PRE; Qudeni, 1830 m., legit. *Davies* 40, *Wood* 7932, K, NH; -do- *Dyer and Collett* 4701, PRE; -do-, 1646 m., *Hilliard* 830, E, K, NU. **Umvoti dist.,** road to Lilani, 930 m., *Hilliard* 835, E, NU, *Hilliard* 1960, K, NH, NU. **Kranskop dist.,** forest patch on Middledrift road near Kranskop, 1128 m., *Hilliard* 833, E, K, NU, PRE, 920, K, NU. **Eshowe dist.,** Ngotshe forest, 610 m., *Hilliard* 1173, E, NU. **Mapumulo dist.,** Fort Cross, 1050 m., *Hilliard* 927, K, NU; near Mapumulo village, 830 m., *Hilliard* 836, E, K, NBG, NH, NU, PRE; 7 mls. Mapumulo on Kranskop road, 1036 m., *Edwards* 3069, NU. **Richmond dist.,** near Richmond, farm "Thedden", 762 m., *Hilliard* 819, NU; Hella-Hella, 960 m., *Hilliard* 1033, NU. **Camperdown dist.,** near Shongweni Station, 427 m., *Hilliard* 820, E, NU; McIntosh Falls on Mhlatuzana river, 563 m., *Hilliard* 818, E, NU. **Ixopo dist.,** near Highflats, 823 m., *Hilliard* 1143, E, K, NU, PRE; near Highflats, Mtwalume Falls, 884 m., *Hilliard* 1144, NU, K, PRE; do., *Strey* sn, NU. **Umzinto dist.,** Kenterton, Ifafa Valley, c. 600 m, *Thode* 4346, STE; c. 1 ml. Braemar, 500 m., *Hilliard* 1145, E, K, NU; Dumisa, *Rudatis* 1288, BM, K. **Alfred dist.,** near Harding, farm "Rooivaal", Xambu river, 700 m., *Hilliard* 1361, E, K, NH, NU, PRE; Shennington, c. 3 mls. NNE Gun Drift, c. 760 m., *Acocks* 12238, PRE; Weza, Mpetyne forest, 1158 m., *Hilliard* 2535, E, K, NH, NU, PRE. **Port Shepstone dist.,** Murchison Plains Black Wattle Co., Izotsha river, 300 m., *Hilliard* 870, E, NU, PRE; Beach Terminus, banks of Izotsha river, 30 m., *Thode* 3982, STE; Oribi Gorge, c. 300 m., *Hilliard* 924, E, NU, 997, 2134, NU; c. 8 mls. Port Edward on Izingolweni road, *Getliffe* sn, NU; sine loc., *Robinson* sn, K, *Sanderson* sn, K.

CAPE: **Tabankulu dist.,** Tabankulu forest, 1219 m., *Hilliard* 2496, NU. **Bizana dist.,** c. 5 mls. Bizana on Flagstaff rd., 1067 m., *Hilliard* 1120, E, K, NU, PRE; between Bizana and Lusikisiki, *West* sn, PRE. **Port St. Johns dist.,** Port St. Johns, Eagles Nest, 170—200 m., *Britten* 6602, PRE, *Codd* 9754, PRE, *Hilliard* 1062, E, K, NU, PRE.

S. haygarthii is extremely variable, particularly in flower size, in corolla colour and markings, and in shape of corolla lobes. There is such marked variation in corolla size and colouring that extremes could easily be mistaken for distinct species. Of the populations so far seen scarcely two are alike. In fact it is sometimes possible to assign specimens precisely to the forest or at least the area from which they came. The one constant feature in corolla form is the "waisted" limb. A number of populations have been sampled and in each this "waist" can be detected, although it is less marked in the southern populations (Fig. 7). Other constant characters are the solitary leaf and the long, relatively slender capsule.

To attempt to split this complex into infraspecific categories would merely create confusion, and *S. haygarthii* is therefore treated as a single variable species. There is in fact no discontinuity in corolla size. Fig. 8 demonstrates the continuous variation in size of corolla limb in thirteen populations. Colour variation in the same populations is listed in Table 1.

S. reynoldsii Verdoorn is reduced to synonymy because the two types from the same locality are indistinguishable.

Causes of variation in *S. haygarthii* cannot be elucidated until a complete biosystematic investigation is undertaken. It is possible that *S. haygarthii* is of hybrid origin and it is suggested that interspecific gene exchange followed by isolation has contributed to variation patterns. Several populations of *S. haygarthii* indicate possible gene exchange with other species still growing in the same area. Suspected gene exchange between *S. polyanthus* ssp. *polyanthus* and *S. haygarthii* in Oribi Gorge has already been mentioned. But a situation similar to that at Kingscliffe (p. 107) has arisen in the forested gorge of the Karkloof river on the farm "The Start", where a uniform, sexually reproducing population displays the characteristics of more than one species (*Hilliard* 1006, E, NU).

Anomalous population on "The Start".

Monocarpic. *Leaf* up to 24 × 20 mm., upper surface medium green, lower paler, often suffused purplish-red on veins. *Inflorescence* many flowers expanded simultaneously. *Peduncle* up to 200 mm. long, green, sparsely pilose. *Bracts* linear, 6 × 1 mm., green, pilose. *Flower* 35 × 40 mm. long. *Pedicel* c. 7 mm. long, elongating slightly in fruit, green, pilose. *Calyx* 5-partite, lobes linear-lanceolate, 6 × 1 mm., green, pilose. *Corolla* tube c. 18 mm. long, base 3 mm. in diam., pale violet adaxially, whitish abaxially, pilose without, minutely glandular within; limb waisted; upper lobes divergent, obovate, c. 13 × 8 mm.; lower lip 15—20 mm. long, lobes elliptic to suborbicular, 10—13 × 9—10 mm.; all lobes medium violet, glandular-pubescent inside, almost white, pubescent outside, yellow blotch in throat. *Stamens:* filaments 4 mm. long, white, sparsely pilose basally, minutely glandular apically; anther lobes 1 mm. long, violet; staminodes minute, violet. *Ovary* 6 mm. long, green, pubescent; style 2 mm. long, green, pubescent; stigma conical. *Capsule* 33—63 (46 ± 7) mm. long, c. 1·5 mm. diam.

The plants resemble *S. haygarthii* in the solitary leaf, the tall, many-flowered inflorescence, and the shape of the corolla limb. But the colour and texture of the corolla is that of *S. polyanthus*. The mean capsule length is shorter than that of *S. haygarthii*, longer and more slender than that of *S. polyanthus* ssp. *verecundus*.

S. haygarthii and *S. polyanthus* are partially sympatric in their distribution range. *S. polyanthus* ssp. *verecundus* has been recorded from several localities near "The Start". It is highly probable that the population on "The Start" is of hybrid origin, although it has become stabilised as a true-breeding entity.

A different situation may, however, arise where *S. haygarthii* is sympatric with another species having different ecological requirements, and where human interference has created an intermediate environment. Hybrid swarms may then occur. Examples are roadside banks on the farm road below Qudeni range and below Isibundini store, Nkandla forest, where *S. haygarthii* and *S. polyanthus* ssp. *verecundus* are the putative parents.

A good example of natural hybridisation is afforded by the *Streptocarpus* populations along the road to Lilani. Access to Lilani is provided by a steep, narrow river valley descending to the Umvoti river. The main valley wall is dissected by numerous streamlets. The road thus passes through a succession of patches of streambank forest separated by grassy shoulders. *S. haygarthii* is found in the forest patches, *S. confusus* on drier but shaded roadside banks or in forest patches that have been trampled out by cattle and goats. *S. polyanthus* ssp. *verecundus* favours the rockier, more exposed roadside banks. Hybridisation occurs freely between *S. confusus* and *S. polyanthus* ssp. *verecundus* and between *S. confusus* and *S. haygarthii*.

The three taxa are readily distinguished by a number of morphological characters, the most striking of which are detailed below. *S. haygarthii* and *S. confusus* have tall, many-flowered inflorescences, while those of *S. polyanthus* ssp. *verecundus* are short and few-flowered. In *S. confusus*, the primary peduncle arises from the apex of the hypocotyl and curls up through the leaf sinus, while in the other two taxa it arises from the upper surface of the leaf. The shape of the limb is different in all three taxa. It is "waisted" in *S. haygarthii*, rounded in *S. polyanthus* ssp. *verecundus*, and oblong in *S. confusus* because of the markedly divaricate upper lobes. Corolla colour and markings are different too; in *S. haygarthii*, the corolla is almost white to very pale violet, sometimes with a yellow blotch in the throat, occasionally with dark violet streaking on the lower lip. The corolla tube is glandular-pilose with occasional acute hairs. The corolla limb of *S. confusus* is rich violet-blue, with a darker violet blotch at the base of the lower lip enhanced by a bright yellow transverse bar in the throat of the tube. The indumentum on the corolla tube is similar to that in *S. haygarthii*. The corolla limb of *S. polyanthus* ssp. *verecundus* is uniform pale to medium violet with no dark lines or blotches, but with a yellow blotch in the throat. The corolla tube is pilose and eglandular. The capsule of *S. confusus* is shorter and stouter than that of *S. haygarthii*, but not as short as that of *S. polyanthus* ssp. *verecundus*.

Bearing these characters in mind, it is easy to detect hybrids, particularly as they occupy only habitats intermediate between those favoured by their putative parents. For example, the peduncle character and rich colouring of *S. confusus* may be evident, combined with the "waisted" limb of *S. haygarthii* (*Hilliard* 3063, NU). In the obvious *S. confusus*, *S. polyanthus* ssp. *verecundus* crosses, the shape, colour and markings of the corolla limb, the corolla tube indumentum, and capsule length are intermediate between those of the parents, and the peduncle character of *S. confusus* may or may not appear. But all possible gradations between the putative parents can be seen in both species crosses.

Much the same situation arises where the road from Kranskop to Middledrift on the Tugela river traverses forest succeeded by a roadside bank, unsheltered except by aspect. *S. haygarthii* is abundant on the steeply sloping forest floor and on roadside banks in the forest. *S. polyanthus* ssp. *verecundus* is found largely on the unsheltered roadside bank. Not only do the two taxa have different habitat preferences, they also differ in a number of constrasting morphological characters which can be summarised briefly. *S. haygarthii: leaf* indumentum patent, upper surface appears dark green (A1), *inflorescence* tall, branched, many-flowered (B1), *corolla* limb "waisted" (C1), varying from white to medium violet with dark marks at base of lower lip (D1), no yellow in throat (E1), *capsule* long, generally 55 mm. or more (F1). *S. polyanthus* ssp. *verecundus: leaf* indumentum appressed, upper surface appears grey-green (A3), *inflorescence* short, unbranched, few-flowered (B3), *corolla* limb rounded (C3), uniform pale violet with no dark markings on lower lip (D3), yellow in throat (E3), *capsule* short, generally less than 40 mm. (F3). Characters intermediate between those of the putative parents are given a value of 2.

If the characters are scored as indicated, selected specimens give the following results:

	A	B	C	D	E	F
Hilliard 3072 (E, NU)	1	1	1	1	1	1
Hilliard 3073 (E, NU)	1	2	1	1	1	2
Hilliard 3074 (E, NU)	1	2	2	2	3	2
Hilliard 3075 (E, NU)	3	3	2	1	3	2
Hilliard 3076 (E, NU)	3	3	3	3	3	3

It is clear that 3072 is typical *haygarthii*, 3076 is typical *polyanthus* ssp. *verecundus*, 3073, 3074, 3075 are obviously intermediate between the two. Such intermediates, showing varying degrees of *haygarthii* and *polyanthus* ssp. *verecundus* influence, are frequent in the transitional zone between forest and relatively unsheltered bank.

Conclusion

S. polyanthus and its allies form a morphologically distinct group showing scant inter-relationship with any other alliance in Southern Africa, except perhaps *S. johannis* and *S. baudertii*, whose flowers bear a superficial resemblance to those of *S. polyanthus*.

S. polyanthus and *S. prolixus*, *S. daviesii* and *S. silvaticus*, and *S. haygarthii* and *S. confusus* constitute closely related species pairs, while *S. pentherianus* remains relatively isolated.

REFERENCES

BRITTEN, L. L. 1940: Some *Streptocarpus* species from the Eastern Cape in Journ. S.A. Bot. **6**: 21–30.

BROWN, N. E. 1905: *S. grandis* in Bot. Mag. t. 8042.

BURTT, B. L. 1939: Kew Bull 68–84.

BURTT, B. L. 1954: Studies in the Gesneriaceae of the Old World. 1. General Introduction in Notes Roy. Bot. Gard. Edin. **21** (4) : 185–187.

BURTT, B. L. 1959: *S. vandeleurii* Bak. f. in Bot. Mag. N.S. t. 341.

CLARKE, C. B. 1904: Gesneriaceae (Gesneraceae) in Thiselton Dyer's Fl. Cap. **4** (2) : 437–447.

FOURCADE, H. G. 1889: Report on the Natal Forests. 197 pp.

FRITSCH, K. 1893: Gesneriaceae in Engl. and Prantl. Die natürlichen Pflanzen-familien, **4** (3B) : 133–185.

FRITSCH, K. 1904: Die Keimflanzen der Gesneriaceen. Jena.

LANJOUW, J. and STAFLEU, F. A. 1964: Index Herbariorum, 5 ed., Utrecht.

LAWRENCE, W. J. C. 1940: The Genus *Streptocarpus* in Jnl. Roy. Hort. Soc. **65** (1) : 17–22.

LAWRENCE, W. J. C. 1958: Studies on *Streptocarpus* Lindl. 5. Speciation and gene systems. Heredity **12**(3) : 333–356.

LAWRENCE, W. J. C., SCOTT-MONCRIEFF, R. and STURGESS, V. C. 1939: Studies on *Streptocarpus:* I Genetics and Chemistry of Flower Colour in the Garden Strains, Jnl. Genetics **38** : 299–306.

OEHLKERS, F. 1938: Bastardierungsversuche in der Gattung *Streptocarpus* Lindl. I. Zeitschr. f. Bot. **32** : 305–393.

OEHLKERS, F. 1942: Factorenanalytische Ergebnisse an Artbarstarden. Biol. Zentral., **62** : 280–289.

STEBBINS, G. LEDYARD. 1949: Variation and Evolution in Plants. Columbia University Press, New York.

NOTES ON MESEMBRYANTHEMUM AND ALLIED GENERA

H. M. L. Bolus

Ruschia lisabeliae L. Bol. sp. nov.—Planta unica visa, fera glabra, ad 90 cm. diam.; rami primarii decumbentes rigidi, ad 60 cm. longi, internodiis brunneis, saepe 2—3·5 cm. longis, 2—4 mm. diam., senectis cum aetate atratis; ramuli ultimi florentes 2-foliati, foliis mox marcescentibus, gemmis axillaribus 2-foliatis; folia ascendentia, supra prope apicem leviter angustata, cum lateribus convexula, dorso rotundo vel carina ad lineam reducta, inconspicue mucronata, viridia, levissima politaque, 2—3·2 cm. longa, 3—5 mm. lata diametroque; flores 3-nati vel 2-ternati vel irregulariter 3-ternati, cymis gracilibus, 4—7·5 cm. longis cum pedunculo primario 2—3·5 cm. longo, 1—1·5 mm. diam., ramis ascendentibus, pedunculis ultimis ad 1·5 cm. longis, infra medium bracteatis; bracteae foliis similes, 3—6 mm. longae; cymae fructiferae ad 17·5 cm. longae; receptaculum subclavatum, ad 3 mm. longum, ad 4 mm. diam., sepala 5, superne leviter angustata, apice breviter subulata, omnia ± marginata, 4—5 mm. longa, basi 1·5—2 mm. lata; petala 3-seriata, e parum supra medium inferne angustata, obtusa vel leviter emarginata, purpureo rosea, ad 11 mm. longa, 0·5—1·5 mm. lata; staminodia nulla; filamenta ca. 4-seriata, mox erecta, purpureo rosea, ad 3 mm. longa, intima prope basim roseo papillata, antheris pollineque luteis; discus inconspicuus crenulatus; ovarii lobi erecti, vix compressi, ad 1 mm. elevati; stigmata profunde posita, inferne anguste subulata, caudata, ad 2·5 mm. longa cum cauda 0·75 mm. longa; capsula infra subclavata, ad 5 mm. longa, supra per 2 mm. elevata, apice fere truncato, suturis vix compressis, 5 mm., expansa ad 6·5 mm., diam., dimidio inferiore valvae patente, superiore erecto, carinis inferne parallelis, superne divergentibus, dimidium valvae attingentibus, tuberculo parvo, processibus 2 apud os loculi dependentibus sat conspicuis.

Cape Province: in dit. Vanrhynsdorp; Hol River, "Sprawling over loose rocklets on east side of a small koppie, 3 or more feet in diameter, 4 or 5 plants seen", Oct. 1965, *H. Hall* 3037.

Named after Mrs. Lisabel Hall who accompanied her husband on this interesting collecting trip.

Sphalmanthus rejuvenalis L. Bol. sp. nov. (*Trichotomi*).—Planta 1 visa, fera glabra senectissima, 25 cm. alta, ca. 26 cm. diam.; caulis lignosus, 1·8 cm. diam., ramos 21, crebres graciles atratos, quasi mortuos, ferens; ramuli hornotini floriferi 4 visi, 7·5—13 cm. longi, internodiis inferioribus 2—3 cm. longis; partes herbaceae sat glauce virides; folia ascendentia, supra plana, dorso rotundo, superne leviter angustata, levissima, ad 3 cm. longa, ad 5 mm. diam.; flores 3-nati meridiani; pedunculi ca. 4 mm. longi; receptaculum globose obconicum, 5 mm. longum, ad 8 mm. diam.; calycis tubus 2 mm. longus, segmentis 4, e medio superne angustatis, obtusis vel subacutis, valde inaequilongis, 1—1·9 cm. longis; corolla ad 1·5 cm. longa, tubo ca. 1·5 mm. longo, segmentis ca. 3-seriatis, obtusis, externe rubicunde aureis, interne salmoneis, basim versus pallidis, ad 0·75 mm. latis; staminodia filiformia, sat pauca; stamina 5—8 mm. longa, antheris pollineque luteis; ovarium ad 1·5 mm. elevatum; stigmata 4, anguste subulata, rubra, 3 mm. longa.

Cape Province: in dit. Vanryhnsdorp; Hol River, Oct. 1965, *H. Hall* 3038. "Only one plant seen, growing on summit of koppie with **Eberlanzia persistens.** The fresh growth sprouting from what appeared to be dead branches was remarkable".

Monilaria brevifolia L. Bol. forma.—A forma typica receptaculo obconico praecipue differt.

This species (with one or two others) differs from the Eumonilaria-group in having some of the internodes elongated or exserted, and the term "Exserta" has been used in my Key to the genera (published in 1958) to distinguish them as a section from the older group.

Three collections of this form made by *H. Hall* are represented in the Bolus Herbarium: at Koekenaap in Oct. 1954 (Bolus Herbarium 25666) and again in Sept. 1955, the third being at Hol River in Oct. 1964 (*Hall* 2866). This plant, with the flowers, which completely veiled it, up to 5 cm. in diameter, was 17—23 cm. in height and 26 cm. and 31 cm. in diameters, the stem up to 4 cm. in diameter. "All the plants at Hol River had glorious rose pink flowers which were a lovely sight on the black stony slopes" (*Hall*).

Amphibolia stayneri L. Bol. sp. nov.—Plantae 4 visae, glabrae, cum floribus ad 7 cm. altae; radix tuberosa, tubere inferne longe angustato, ad 6 cm. longo, prope apicem ad 1·2 cm. diam.; rami primarii ad 5 mm. diam., hornotini graciles brunnei, ad 1·5 mm. diam., interdum prope basim squama onusti, internodiis saepius 1 cm. longis vel in ramulis inclusis; folia ascendentia, supra plana, fere e medio superne angustata, acuta, conspicue mucronata, viridia scabrida, ad 1·7 cm. longa, medio 1·5—2 mm. lato diametroque, vel rarius ovata vel lanceolate ovata, carina obscura, 6—8 mm. longa, vagina ad 1.5 mm. longa; flores solitarii meridiani, ad 2 cm. diam.; pedunculi teretes graciles, a receptaculo distincti; bracteae basales, foliis similes; receptaculum globose obconicum, prope apicem leviter constrictum, ad 3 mm. longum, 5—6 mm. diam.; sepala 5, fere e basi angustata, mucronata, ad 5—6 mm. longa, basi 2—4 mm. lata, interiora 3 marginata; petala ca. 2-seriata, inferne ex infra medium et prope apicem leviter angustata, acuta vel obtusa, purpureo rosea, saturatiore utrimque vittata, 6—7 mm. longa, ad 0·75 mm. lata; staminodia ad stamina conice conferta appressa eaque leviter excedentia, acuminata, inferne pallida, superne purpureo rosea; filamenta ca. 4—5-seriata, ad 3·5 mm. longa, intima supra medium dense papillata, antheris pollineque primum pallide luteis; discus crenulatus vel profunde denticulatus; ovarii lobi obtuse compressi, sat distantes, discum attingentes, leviter elevati; stigmata 5, inferne anguste subulata, fimbriata viridia, ad 3·5 mm. longa cum cauda 1 mm. longa; capsulae senectae tantum visae, infra globose obconicae, 4 mm. longae, 7 mm., expansae 1·3 cm., diam., tuberculo parvo, carinis parallelis in dimidio inferiore valvae, in dimidio superiore late divergentibus, dimidium valvae attingentibus, alis liberis in dimidio superiore.

Cape Province: in dit. Ceres; "between Matroosberg and Theronsberg Pass, 4,000 ft.", Sept. 1965, *F. J. Stayner*. Karoo Garden 258/65.

Astridia vanbredai L. Bol. sp. nov.—Planta 1 visa, glabra, ca. 26 cm. alta, caule ad 9 mm. diam.; ramuli ultimi 6-foliati; folia fere erecta vel demum late patentia, interdum subfalcata, supra e medio superne angustata, acuta vel acuminata, lat. visa e supra medium angustata, acuta vel obtusa, 4—5 cm. longa, 6—8 mm. lata, 8—10 mm. diam., eis bracteas subtendentibus 2—3 cm. longis; bracteae manu complanatae in dimidio inferiore circulatae, ad 1·2 cm. diam., in superiore ovatae acutissimae, ad 1·3 cm. longae, 5 mm. diam.; receptaculum 2—3 mm., vel rarius ad 4 mm., longum, ad 1 cm. diam.; sepala exteriora obtusa, interiora in dimidio superiore acute vel obtuse subulata, 8—12 mm. longa, basi 3—9 mm. lata; petala ca. 4-seriata, e supra medium inferne angustata, saepius obtusa vel rotunda, laete purpureo rubra, prope basim pallida, 1·7—3 cm. longa, 0·5—3 mm. lata; staminodia pallida vel prope apicem rubra, stamina aequantia vel excedentia; filamenta 6—7-seriata, exteriora ciliate papillata, interiora interdum dense papillata, alba vel exteriora aurea vel rubra, antheris pollineque aureis; ovarii lobi erecti, ad 2 mm. elevati; stigmata inferne angustissime subulata, longe attenuata, 4—5 mm. longa, cauda brevissima; capsula senecta tantum visa, infra brevissime obconica, ca. 2 mm. longa, ca. 1·1 cm., expansa 1·4 cm., diam., valvis fere erectis manentibus, supra per 4 mm. elevata, carinis medium valvae, vel parum ultra, attingentibus, inferne parallelis distantibusque, deinde late divergentibus incurvatisque, arista ca. 1 mm. longa; semina non visa.

Cape Province: Namaqualand; Helskloof, *P. A. B. van Breda* 1694/60. Fl. Veld Reserve, Worcester, Jun. 1962, Feb. 1964, et Mart. 1965.

Lampranthus proximus L. Bol. sp. nov.—Ad **L. prominulum** (L. Bol.) L. Bol. valde affinis, sed punctis multo minus prominentibus, petalis inferne minus angustatis, brevioribus latioribusque, staminodiis paucissimis, filamentis longioribus, stigmatibus inferne angustissime subulatis, stamina interdum superantibus differt.

Petala ad 1 cm. longa, ad 2 mm. lata; filamenta 2—3-seriata, ad 4·5 mm. longa, antheris pollineque primum luteis; capsula infra obconica, 5 mm. longa, ad 6 mm., expansa 1·1 cm., diam., supra per 2 mm. elevata, suturis compressis, carinis parallelis, cum alis apicem valvae attingentibus.

Cape Province: in dit. Cape; Fisantekraal, "near Klapmuts turn-off to Agter Paarl", Sept. 1965, *J. E. Nel*. Bolus Herbarium 27738.

Of this area Dr. Nel writes: "Nowhere else have I seen such an immense variety of small flowers as found on this area of undisturbed veld during early spring".

Gibbaeum haagei Schwant. var. **parviflorum** L. Bol. var. nov.—Plantae plures visae, senectae, ad 15 cm. et 13 cm. diam., medio 7 cm. alto; ramuli hornotini floriferi 2-foliati, sed quasi 4-foliati ob gemmam axillarem bene evolutam (ut in genere solitam est); partes herbaceae minutissime pubescentes, tactu velutino; folia matura supra visa late ovata, acuta, lateraliter visa in longioribus apice rotundo vel subtruncato, in brevioribus obliquo, abrupte acuto (novella ad 1·3 cm. longa aequilonga et similia), ad 5·5 cm. et 3·5 cm. longa, ad 2·7 cm. lata, longioribus ad 2 cm., brevioribus ad 3 cm., diam.; pedunculi ad 1·5 mm. longi; receptaculum compressum, 4—5 mm. et 7—12 mm. diam., in pedunculum insensim transeuns; sepala 6, omnia compressa carinataque, exteriora 1—1·3 cm. longa, 4—5 mm. diam., interiora 5—6 mm. vel 5—8 mm. longa, 1·5—2 mm. diam.; petala exteriora 2-seriata, parum inaequilonga, ad 11 mm. longa, ad 1·25 mm. lata, e parum supra medium inferne leviter angustata, purpureo rosea, inferne vittata, vitta superne saepe obscura, interiora pauca, acuminata, in staminodia transeuntia, ad 7 mm. longa; staminodia acuminata pallida, stamina longissima aequantia vel excedentia; filamenta ca. 5-seriata, alba, intima obscure papillata vel nuda, ad 5 mm. longa, antheris pollineque luteis; glandulae approximatae conspicuae; ovarii lobi erecti distantes, superne obtuse compressi, ca. ad 1·5 mm. elevati.

Cape Province; in dit. Swellendam; "on the farms 'Uitvlugt' and 'Witkop'", *P. A. B. van Breda* 1754/62. Fl. Veld Reserve, Worcester, Oct. 1964. "This was first collected on the farm "Uitvlught", Swellendam District. Then we visited the farm "Witkop" and found the plant even more plentiful there. They grow on gravelly patches or pans in such numbers that one could not avoid treading on the plants". (*P. A. B. van Breda*).

Octopoma conjunctum (L. Bol.) L. Bol. comb. nov. *Ruschia conjuncta* L. Bol., Mesemb. II: 239.

NOTE.—The type specimens of all new species described in this paper are in the Bolus Herbarium, University of Cape Town.

(*To be continued*)

STUDIES IN CYPERACEAE IN SOUTHERN AFRICA: III

Two New Species of *Fimbristylis* Vahl

KATHLEEN D. GORDON-GRAY

Bews Botanical Laboratories, University of Natal, Pietermaritzburg

ABSTRACT

Two new species of *Fimbristylis* Vahl are described for Southern Africa. *F. hygrophila* has affinities with section Abildgaardia Vahl, while *F. variegata* shows relationship with section Fuscae Ohwi. The distribution of the former species is known to extend to Tropical Africa.

Fimbristylis hygrophila Gordon-Gray sp. nov.

Perennis, erectus, vel paullo languidus, ad 44 cm. longus, caespitosus: *rhizoma* ligneum, contractum, manifestum fruticeto abrupto, ad 5 mm. latum, latitudine omni modo, saepe oblique perpendiculus in solo, luridus vel fuscus folliis leviter spongiosis efficiens tunicam rhizomati: *folia* solum vaginarum; vaginae solidae, solide vestientes culmo rotundae, molle, spongiosa, glabrae, multis nervis, anastomosis prope os antequum incedunt diminuta laminas; carina non perspicua; membranacea pars interdum deficiente, plerumque minuta triangula maculosa area ad basim vaginae oris et ad marginem declivi oris; *ligula* brevis membranacea margo vaginae oris adaxialis ad laminas; *laminae* obsoletae, ad 3 mm. longae, filiforme, apiculatae, glabrae, tandem caducae: *culmi* manifesti, plerumque erecti, interdum leviter languidi, rotundi languidi striati, glaber: *pars inflorescens* mutabilis, ad 23 mm. in longitudinem, ad 35 mm. in latitudinem, ex umbella simplici composita unius spicae sessilis cum 1—4 pedicellatis spicis additis, vel cum uno capite 4—2 sessilium spicarum, vel capitis 2—4 spicarum cum 1—4 pedicellatis capitibus, vel pedicillatis spicis additis, vel unius sessilis spicae solum; omnibus vel nonnullis facultatibus repraesentatis in singularibus plantis; pedicelli ad 10 mm. longi, similes culmis inflorescentibus sed complantiores; *bracteae* 2—4, ad 5 mm. longae, nunquam magis pars inflorescens, simile squamis sed minores cum apiculo, ad 2 mm. longo; *spicae* 10—22 mm. longae, 3—9 mm. latae, oblongae vel oblonge-lanceolatae, densae in immaturitate, ellipticae vel ovatae, lacerae in senectute, in inferior ex partis languide compressae, aliter rotundae, lucentes luridae vel flavae, inferiores squamae premature caducae; *rachilla* manifeste tortuosa; breviter alatae; alae non manifestae, mox marcescentes, fuscae, maculosae:

squamae imbricatae, solide vestientes rachillas in immaturitate, mox patentes et facientes spicam laceram, infimae 1—2 infecundae, similes bracteis, reliquae fecundae, 6·1—8·2 mm. longae, 3·2—4·3 mm. latae, naviculare, ovatae, glabrae, flaventes; margo luridus, membranosus, conspicuus sum aridus; carina rotunda manifeste cum arida, cum tribus nervis excurrentibus in mucronatum; apex acutus, mucronatus, mucro ad 1 mm. longus in squamis inferioribus: *stamina* 3; *anthera* 2·5—3·3 mm. longa, flava vel lurida cum fuscis, longitudinis maculis; crista pyramidata, fusca, cum minutis auriculari; *stylus* 5·3—7·1 mm· longus includens styli basem, triquetra vel languida alata; iugi pilosi in superiore parte, glabri in inferiore parte, luridi vel fusci; *styli basis* breviter pyramidata, 0·5—0·6 mm. longa cum tribus alis manifestis, margines facierum patentes super apicem nucis fusci, *rami styli* 3, aequalis stylus; *nux* 1·2—1·4 mm. longa, 0·8—1·1 mm. lata, triquetra, late obovata similis piro cum ungula brevi, nivea, *superficies* languida reticulata, manifesta transversa striata, *cellulae exteriorae* subquadratae, transverse elongato super iuga.

TYPE LOCALITY: Natal, Port Shepstone distr.: Port Edward, in damp black mud of vlei opposite Post Office; alt. approx. 30 ft.; collected January, 1951; K. D. Huntley 701 (NU holotype: NU, K, BM, L, PRU, NBG, PRE, BOL isotypes).

ZAMBIA. Chingola distr.: 11 km. n. of Chingola. *Robinson* 4224 (NU, EARO); Luanshya distr.: Ibenga, 18 ml. s. of Luanshya, *Robinson* 3316 (NU, EARO).

TRANSVAAL. Barberton distr.: Mhlambanyati Pan, *Michelmore* 49 (PRE).

NATAL. Ingwavuma distr.: Black Rock area, *Tinley* 307 (NPGF, NU); n.e. Maputa near P.E.A. border, *Ward* 3233 (NPGF, NU); Kosi Bay, *Meyer* s.n. (NU); Hlabisa distr.: w. of Charter's Creek, *Ward* 2794 (NU, NPGF); near Fanie's Island, *Ward* 1479 (NU, NH, NPGF); e. shores St. Lucia, *Ward* 1482 (NU, NH, NPGF); do. *Feely & Ward* 14 (NPGF); Mtunzini distr.: slopes of Ongoye above Ongoye Mission, *Bayer* s.n. (NU); Durban distr.: Clairmont, *Schlechter* 3132 (K, GRA); Stainbank Nature Reserve, Coedmore, *Ward* 4822 (NU, IU); Port Shepstone distr.: Port Edward, *Ward* 3491 (NU, NPGF); Trafalgar, *McNeil* 137 (NU); Uvongo Beach, *Gordon-Gray* 4499 (NU).

Perennial, erect or slightly drooping, up to 44 cm. in height, densely tufted: *rhizome* woody, contracted, conspicuous only when tufts broken apart, up to 5 mm. wide of uniform thickness throughout, usually obliquely vertical in soil, clothed by pale yellow to light brown rather spongy leaf bases, forming, usually, a persistent tunic to rhizome: *leaves* limited to sheaths only; *sheaths* entire, closely investing flowering stems, rounded, soft, spongy, glabrous, many nerved, nerves anastomosing near mouth before passing into reduced blade, keel undefined, membranous portion occasionally wanting, usually limited to

small triangular, brown-speckled portion at base of sheath mouth and margin of sloping mouth; *ligule* short membranous margin of sheath mouth adaxial to blade; *blades* obsolete, never exceeding 3 mm. long, filiform, the apiculate continuation of main nerves of sheath, glabrous, eventually deciduous: *flowering stems* conspicuous, usually erect, occasionally slightly drooping, terete, faintly ridged and furrowed, glabrous: *inflorescence* variable, up to 23 mm. long, by 35 mm. wide, a simple "umbel" of one sessile spikelet with 1—4 pedicelled spikelets added, or a single head of 2—4 sessile spikelets, or a head of 2—4 sessile spikelets with 1—4 additional pedicelled heads or pedicelled spikelets added, or 1 sessile spikelet only, all, or several possibilities being represented on single plants; *pedicels* up to 10 mm. long, as flowering stems but more compressed; *bracts* 2—4, up to 5 mm. long, never exceeding inflorescence, glume-like with apiculis up to 2 mm. long: *spikelets* 10—22 mm. long, 3—9 mm. broad, slightly compressed in lower half otherwise cylindric, oblong to oblong-lanceolate, compact when young, elliptic to ovate, ragged in age, biscuit to golden yellow, shining, basal glumes early deciduous; *rachilla* appearing twisted, wings short, inconspicuous, soon drying, shrivelling and appearing absent, brown with darker speckles: *glumes* adpressed to rachilla in young spikelets, soon spreading at 45° giving spikelet ragged outline, lowest 1—2 sterile, bract-like, remainder fertile 6·1—8·2 mm. long, 3·2—4·3 mm. in total width, ovate, glabrous, golden yellow with broad, pallid, faintly brown-speckled, membranous margin obvious when dry, keel rounded, well marked especially when dry, of 3 green to cream nerves excurrent into mucron, up to 1 mm. long in lowest glumes, apex acute, mucronate: *stamens* 3; *anthers* 2·5—3·3 mm. long, yellow to cream with dark brown longitudinal markings, crest pyramidal, clearly defined, dark brown: *style* 5·3—7·1 mm. long including style base, 3 angled to slightly winged, angles long ciliate to villous in upper $\frac{2}{3}$, glabrous below, pallid to brown, *style base* shortly pyramidal, approx. 0·5—0·6 mm. long, markedly 3 winged, bases of flat faces wing-like extending over apex of nut, mid to dark brown, branches 3, approx. equalling style, brown to dark brown: *achene* 1·2—1·4 mm. long, 0·8—1·1 mm. broad, trigonous, broadly obovate almost pyriform, apex shortly projecting; narrowed base (claw) short, approx. $\frac{1}{4}$ total nut length, crystalline white, with greenish brown of testa discernable through pericarp, *surface* faintly reticulate, markedly transversely ribbed; *outermost cells to pericarp* subquadrate, transversely elongate over ridges. *Flowering period* August to March inclusive.

The specific name refers to the form of the vegetative organs which are characteristically those of a marsh species. The winged style base and the undeveloped leaf blades, both distinctive features of the taxon, have already been reflected in names previously applied within the genus.

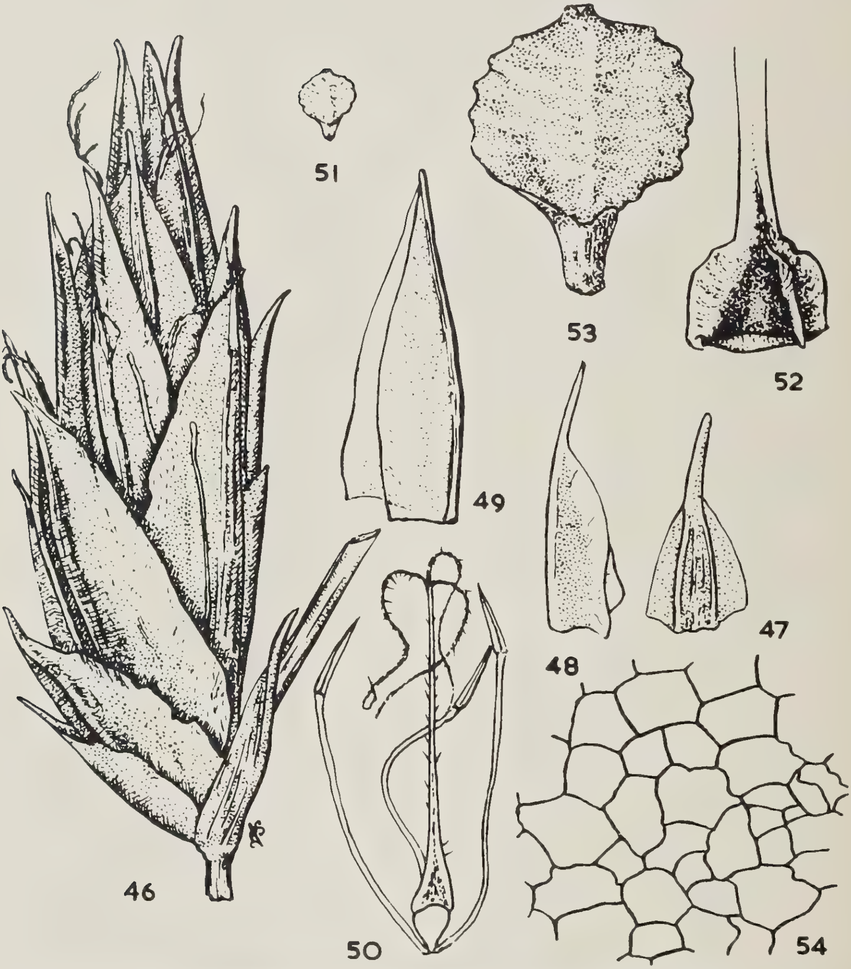


FIG. 1. *Fimbristylis hygrophila* Gordon-Gray sp. nov. (Huntley 701) 46, spikelet; 47, 48, two basal glumes; 49, fifth glume from spikelet base; 50, young floret; 51, achene (all × 10); 52, style and style base (× 20); 53, achene (× 40); 54, epidermal cells to pericarp (× 280).

In August, 1893, Schlechter (3132) collected the species from Clairmont, near Durban, Natal. It was named *F. monostachyos* (L.) Hassk. with the result that it remained apparently unnoticed. On the sheet of Schlechter 3132 in Albany Museum, Schonland wrote, "vidi Wood 10428, 'Maritzburg, alt. 2–3,000 ft.". The two specimens do not match, however, for Wood 10428 is a fairly robust example of *F. monostachyos*. A subsequent gathering of the new species in 1941, Michelmore 49, remained unidentified, but material collected from Lusikisiki in 1947 by Acocks was also named *F. monostachyos*.

Subsequent field investigation, particularly by C. J. Ward, has revealed that the taxon is well represented along the south eastern African coast from Kosi Bay in the north to the Transkei in the south. Recently specimens were found by Mr. Ward at Coedmore, very close indeed to Schlechter's original locality.

Michelmore's gathering is of interest, for the locality, "Mhlambanyati Pan", is probably in the vicinity of the river of that name in the Transvaal, rather than near Hlambanyati in Swaziland. Whichever is correct, this specimen extends the known distribution for the species further inland than has been recorded in Natal and forms a tenuous link with the specimens collected from dambos in Zambia by E. A. Robinson in 1960–61.

It is probable that the distribution of *F. hygrophila* in Africa, south of the Sahara, follows that of so many tropical sedges, namely across the continent in the tropics, becoming restricted to the coastal plain with increasing southerly latitude and eventually reaching the limit of distribution in South Africa about the mouth of the Great Fish River. For *F. hygrophila*, the hiatus between Zambia and the Transvaal, or Swaziland, remains to be bridged, while distribution north of Zambia remains completely unknown.

In Southern Africa, plants appear confined to sandy, black turf soils of vlei areas where abundant, sometimes more or less stagnant and slightly saline, water of the high water table is available for the major part of the year. Slightly drier conditions can be withstood, provided these do not persist indefinitely. In such vlei areas the species is often dominant, sometimes forming pure stands in lower lying parts. More commonly it occurs together with other sedges, particularly *Fimbristylis complanata* (Retz.) Link and grasses, for example, *Sporobolus subtilis* Kunth.

In Zambia the species seems confined to dambos.

In Northern Rhodesia the species seems confined to dambos.

Among Southern African species, *F. hygrophila* is most closely related to *F. monostachyos* and *F. triflora* (L.) K. Schum. In the mature state it is readily distinguished from these, however, by a number of well marked characters, namely, the well developed rhizome growing, as a rule, obliquely vertically in the soil and clothed by soft, spongy, persistent leaf bases; the undeveloped leaf blades; the biscuit to golden yellow glumes that on close inspection show broad, pale brownish membranous margins; the tendency of the glumes to project from the rachilla at approximately forty-five degrees giving the spikelet a ragged appearance; the well developed three winged style base that fits closely over the nut apex, so that its three flat faces form three thin "curtains" of tissue overspreading the apical portion of the achene; the clearly marked transverse waving of the upper portion of the achene.

When immature, these features, particularly of spikelets and achenes, are not well marked and confusion with *F. monstachyos* and *F. triflora* is more readily possible.

Until world species have been considered, when closer affinities may be found for *F. hygrophila*, this species is best placed in section Abildgaardia, (Pax, 1889; Kern, 1955), together with *F. monostachyos* and *F. triflora*, on the basis of the slight flattening of the spikelet in its basal half, the colour and texture of the glumes, the development of wings to the style base and the pyriform nut.

Fimbristylis variegata Gordon-Gray sp. nov.

Perennis, erectus vel paullo languidus, ad 45 cm. longus, caespitosus: *rhizoma* ligneum, contractum, plerumque manifestum fruticeto abrupto vel persistentibus vaginis tritis, ad 5 mm. latum, latitudine omni modo, saepe oblique perpendiculus in solo, nonnunquam transversus, luridus vel rubidus foliis leviter spongiosis efficiens tunicam rhizomati tandem detritus: *folia* solum vaginarum; vaginae solide vestientes culmo rotundae, interdum obscure carine, molle, leviter spongiosa, glabrae, multis nervis anastomosis prope os antequum incedunt diminuta laminas; carina languide evoluta; membranacea pars plerumque deficiente, interdum minuta triangula area ad basim vaginae oris et ad marginem declivis oris; *ligula* brevis membranacea margo vaginae oris adaxialis ad laminas; *laminae* obsoletae, ad 3 mm. longae, filiforme, apiculatae glabrae: *culmi* manifesti, plerumque erectis, interdum leviter languidi, rotundi, vel paullo complanatis infra umbellam cum iugis et sulcis, glaber: *pars inflorescens* ad 12 mm. in longitudinem, ad 11 mm. in latitudinem, plerumque unico capite 2—9 solide sessilibus vel sub-sessilibus spicis, interdum 2 vel pluris pedicellatis spicis efficiens diminutam simplicem umbellam, vel capita reducta ad unum sessilem spicem, omnibus facultatibus repraesentatis in singularibus plantis; pedicelli simile culmis sed tenuiores; *bracteae* 2—3, ad 3 mm. longae nunquam magis inflorescentes, simile squamis sed minores, cum apiculo ad 1·5 mm. longo, pallido; *spicae* 6·0—8·2 mm. longae, 2·2—3·1 mm. latae, angustae ovatae vel ellipticis, densae in inferior ex partis compressae aliter rotundae, interdum compressae omni modi lucentes rufae cum rubidis maculis, basis squamae tarde caducae: *rachillae* tortuosae, languide alatae, rubidae, nuces plerumque persistente post casum squamarum: squamae imbricatae, infimae 1—2 infecundae, reliquae fecundae 3·5—3·9 mm. longae, 2·3—2·6 mm. latae, naviculare, ovatae, glabrae, flaventes vel fulvae cum rubidis maculis; margo luridus membranosus conspicuus cum aridus, carina rotunda cum 3-nervis fulvis vel luridis excurrentibus in apicem acutum, mucronatum, mucro ad 0·5 mm. longus in squamis inferioribus brevior in superioribus; *stamina* 3, *anthera* 1·6—2·2 mm. longa, fulvacum rubidis maculis, vel rubida; crista linearis vel oblonga papillata cum basi auriculari: stylus 2·3—2·5 mm. longus includens styli basi, triangulatus vel paullo alatus, apex cilatus in angulum, basis glabra lurida vel fusca; *styli basis* breviter pyramidalis, 0·3 mm. longa, triangulata vel trialata; bases alarum patentes et legentes apicem nucis: *rami styli* 3, aequale styli vel superans stylum, fusci: *nux* 1·1—1·3 mm. longa, 0·7—0·8 mm. lata, triquetra obovata, lurida vel rufa, *superficies* languida transverse et longitudine striata, *cellulae exteriorae* transverse elongato disposita in lineo perpendiculo.

TYPE LOCALITY: Natal, Port Shepstone distr.: Port Edward, Izingolweni Rd., in shallow soil on ledge of sandstone outcrop on ridge inland from Port Edward village; alt. approx. 300 ft.; collected January, 1951; K. D. Huntley 734 (NU holotype: NU, K, BM, L, PRU, NBG, PRE, BOL isotypes).

NATAL. Port Shepstone distr.: Oribi Flats, *McClean* 380 (NH, PRE).

CAPE PROVINCE: Bizana distr.: Sea View near Redoubt, *Ward* 1108, 1115 (NU).

Perennial, erect or slightly drooping, up to 45 cm. in height, densely tufted: rhizome woody, contracted, conspicuous only when tufts broken apart, or when persistent leaf sheaths wear away, up to 5 mm. in diameter, of uniform thickness throughout, frequently obliquely vertical in soil, sometimes transverse, clothed by pale to reddish brown, slightly spongy leaf bases forming tunic to rhizome, eventually wearing away: *leaves* limited to sheaths only; *sheaths* closely investing flowering stems, rounded, occasionally indistinctly keeled, soft, slightly spongy, glabrous, many nerved, nerves anastomosing near mouth before passing into reduced blade, keel poorly developed, membranous portion usually wanting, occasionally limited to minute triangular area at base of sheath mouth and margin of sloping mouth; *ligule* short membranous margin of sheath mouth adaxial to blade; *blades* obsolete, up to 3 mm. long, filiform, the apiculate continuation of main nerves of sheath, glabrous: *flowering stems* usually erect, occasionally slightly drooping, terete to slightly flattened below inflorescence, ridged and furrowed, glabrous: *inflorescence* up to 12 mm. long, up to 11 mm. broad, usually a single head of 2—9 closely packed sessile, or sub-sessile, spikelets, occasionally 2 or more spikelets pedicelled forming a reduced simple "umbel", or heads reduced to one sessile spikelet, all possibilities represented on single plants; *pedicels* as flowering stems, more slender;

bracts 2—3, up to 3 mm. long, never exceeding inflorescence, glume-like but apiculi up to 1·5 mm. long: *spikelets* 6·0—8·2 mm. long, 2·2—3·1 mm. wide, compact, compressed in lower half, otherwise cylindric, occasionally compressed throughout, narrowly ovate to elliptic, shining buff to light brown with chestnut red markings, basal glumes tardily deciduous; *rachilla* straight, scarcely winged, chestnut red, nuts often persisting after glumes are shed: *glumes*, lowest 1—2 sterile, bract-like, remainder fertile, 3·5—3·9 mm. long, 2·3—2·6 mm. in total width, ovate, glabrous, golden yellow to buff with chestnut red markings,

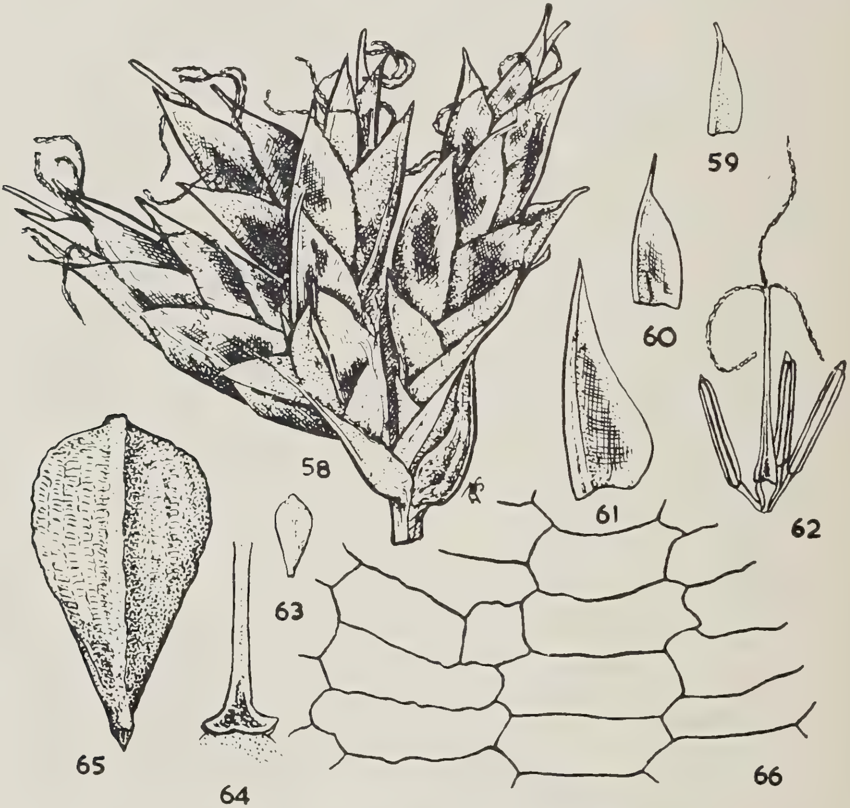


FIG. 2. *Fimbristylis variegata* Gordon-Gray sp. nov. (Huntley 734) 58, single head of four spikelets; 59, 60, two basal glumes; 61, fifth glume from spikelet base; 62, young floret; 63, achene (all × 10); 64, style and style base (× 20); 65, achene (× 40); 66, epidermal cells to pericarp (× 280).

margin pallid, membranous, conspicuous when dry, keel rounded, of 3 yellow to buff nerves excurrent into mucron up to 0·5 mm. long in basal glumes, shorter in upper, apex acute, mucronate: *stamens* 3; *anthers* 1·6—2·2 mm. long, golden brown with chestnut red markings, or chestnut red, crest linear to oblong, clearly defined, papillate; style 2·3—2·5 mm. long including style base, 3-angled to slightly winged, angles ciliate in upper $\frac{2}{3}$, glabrous below, pallid to brown, *style base* shortly pyramidal, approx. 0·3 mm. long, 3-angled to 3-winged, bases of angles prolonged, wing-like, overlying apex of nut, branches 3, equalling or slightly exceeding style, dark brown: *achene* 1·1—1·3 mm. long, 0·7—0·8 mm. wide, trigonous, obovate, apex rounded, cream to pale brown, *surface* faintly transversely and longitudinally striated: *outermost cells to pericarp* transversely elongate, placed in vertical series. Flowering period December to April according to present knowledge.

The specific name refers to the golden buff and chestnut red variegation of the glumes, which gives the spikelet a speckled appearance.

The first collection of the species appears to have been in 1937 by McClean (380) from Oribi Flats, near Port Shepstone, Natal. The two sheets of this number each bear the comment, "nearest *F. complanata* Link var. *kraussiana*, but not matched exactly.".

In form of the achene and shape of its epidermal pericarp cells, there is affinity with *F. complanata*, but this is not well substantiated by other features of structure.

Closer relationship is with *F. hygrophila* sp. nov., but this also is not particularly well marked. Vegetative organs are closely alike, except that leaf bases in *F. variegata* are more slender, less spongy and reddish brown when young. Floral parts, with the exception of the nut, are considerably smaller than in *F. hygrophila* and differ in many details of structure so that these organs supply a number of features whereby the two species may be distinguished, namely, achene shape, size and colour, and form of the epidermal pericarp cells; spikelet, glume and anther size; style base form.

Following Kern, (1955) the species must be placed in section Fuscae because of the slight flattening of the spikelet in its basal half, due to a distichous arrangement of lower glumes, and the obovate nut, which, however, is not particularly small. Should this arrangement persist after consideration among world species, *F. variegata* will be the first Southern African representative of this section.

HERBARIUM ABBREVIATIONS

The Herbarium abbreviations used are those listed by Lanjouw and Stafleu (1964). In addition the following abbreviations are also included:

NPGF—Herbarium of the Natal Parks, Game and Fish Preservation Board, Hluhluwe Game Reserve, Zululand.

IU—Herbarium of the University College, Salisbury Island, Durban, Natal.

EARO—Private Herbarium, E. A. Robinson Esq., Lusaka, Zambia.

ACKNOWLEDGEMENTS

Grateful appreciation is extended to the Directors of Herbaria for the loan of material for study; to Mr. C. J. Ward for intensive collection and field study of the species in Natal; to Mr. E. A. Robinson for loan of specimens from his private Herbarium and for useful field notes; to Prof. S. Davis for guidance in composition of Latin descriptions.

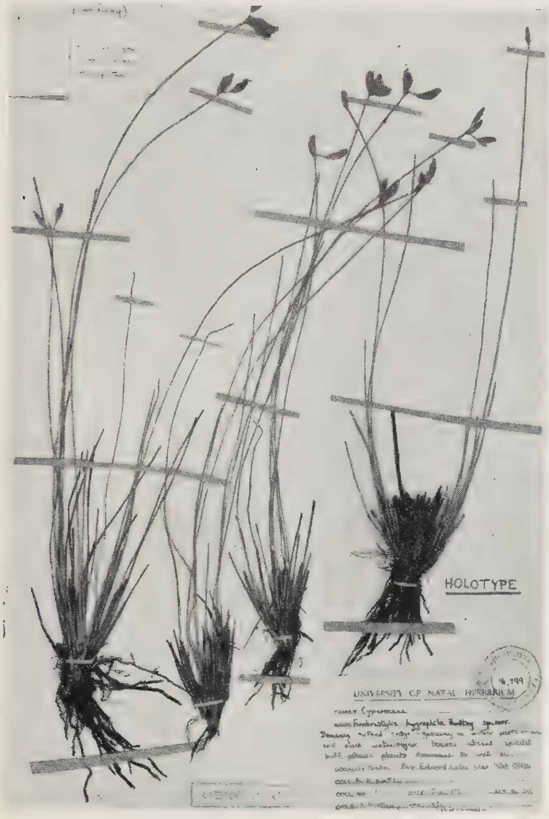
The author also wishes to thank Mrs. P. Stuckenberg for clear black and white illustrations; Mr. D. Tunnington, for photography of herbarium sheets and achenes, and Prof. A. Bayer, for helpful suggestions relating to the photography of small objects.

REFERENCES

KERN, J. H. 1955. *Florae Malesianae Precursores.* X. Notes on Malaysian and some S.E. African Cyperaceae. Blumea **VIII**, 1: 158–161.

LANJOUW, J. & STAFLEU, F. A. 1964. *Regnum Veget.* 31. Index Herbariorum **I**. The Herbaria of the World, ed. 5: 205–228.

PAX, F. 1889. Cyperaceae. *In* Engler, A. & Prantl, K., *Die Naturlichen Pflanzen-familien*, **II**. 2: 98–126.


HOLOTYPE
UNIVERSITY OF NATAL HERBARIUM
Cyperaceae
Fimbristylis hygrophila Huntley sp. nov.

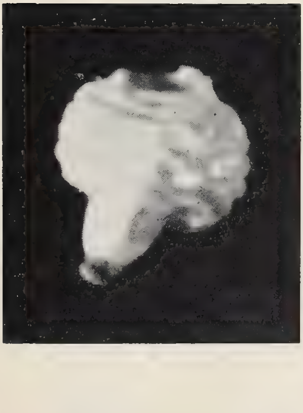
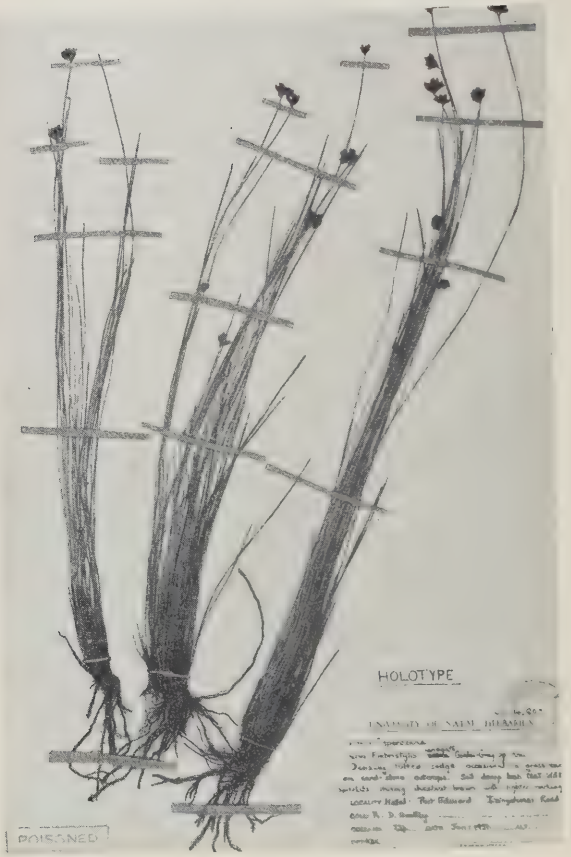


PLATE I.
Fimbristylis hygrophila Gordon-Gray sp. nov. holotype, Huntley 701; below, achene (× 30).

MARY GUNN LIBRARY
NATIONAL BOTANICAL INSTITUTE
PRIVATE BAG X 101
PRETORIA 0001
REPUBLIC OF SOUTH AFRICA



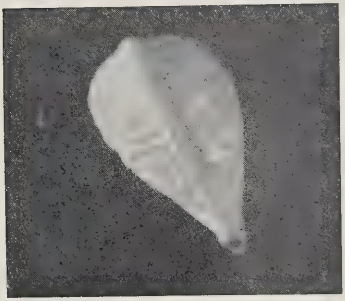


PLATE II.
Fimbristylis variegata Gordon-Gray sp. nov. holotype, Huntley 734; below, achene (× 30).

JOURNAL
OF
SOUTH AFRICAN BOTANY
VOL. 32

Published: 1st April, 1966

STUDIES IN CYPERACEAE IN SOUTHERN AFRICA: IV

Fimbristylis species of section Abildgaardia (Vahl) Benth.

Kathleen D. Gordon-Gray

(*Bews Botanical Laboratories, University of Natal, Pietermaritzburg*)

Abstract

Descriptions, illustrations and citations of specimens of *Fimbristylis monostachyos*, type species of section Abildgaardia, and its ally, *F. triflora*, are given. The close morphological relationship between these species is discussed.

Introduction

Of the eighteen sections recognised within *Fimbristylis* Vahl by Kern (1955), three were differentiated on distichously arranged floral glumes. In two of these, Abildgaardia (Vahl) Benth. and Fuscae Ohwi, rachillas were persistent with the glumes spirally arranged in the upper two-thirds of the spikelet. Further distinction depended upon achene structure, nuts being large, pyriform and tuberculate in Abildgaardia; small, obovate, smooth or verruculose in Fuscae. Both sections included only trigynous species with three-angled achenes and triquetrous styles developing three apical branches.

Koyama (1961), because of failure to delimit subgenera since, "the morphological uniformity of *Fimbristylis* makes it very difficult to circumscribe the infrageneric groups . . .," recognised related species as series rather than sections. In series Monostachyae Ohwi, he united both Abildgaardia and Fuscae of Kern (l.c.), ignoring in so doing, differences in achene structure. Koyama also placed little emphasis on two-ranked basal glumes, for he regarded Abildgaardia as an extreme group of Trichelostylis (Lestib.) Boeck. in a broad sense, in which section species such as *F. complanata* (Retz.) Link and *F. microcarya* F.v.M. with glumes spiral throughout the spikelet, are placed.

Kern's arrangement seems to reflect more closely relationships apparent from external morphology, so that at the present stage of investigation it is preferred.

Two recently described Southern African species, *F. hygrophila* and *F. variegata* (Gordon-Gray, 1965), were tentatively referred to sections Abildgaardia and Fuscae respectively, pending detection of closer affinities when world integration of regional studies is possible. Achenes in the former are transversely ribbed not tuberculate, while in *F. variegata* they are not small. Evaluation of such structural differences with only the present understanding of sectional relationships to guide, is difficult.

Two other long established species, both well represented in Southern and Tropical Africa, fall without question within Abildgaardia, for *F. monostachyos* (L.) Hassk. is the type species of this section, while *F. triflora* (L.) K. Schum. shows close affinity with *F. monostachyos*.

Descriptions of species in this and in subsequent papers, except where otherwise stated, are based on field and laboratory observation of living material, together with study of herbarium specimens in conjunction with available literature. When measurements are recorded, the limits of actual measurements are followed, in parenthesis, by the mean and standard error of the mean. The two last named parameters were calculated from measurements of not less than twenty specimens from localities widely spread throughout the range of distribution in Southern Africa.[1]

Representative citations only are published, but complete lists of all specimens studied are available in the Herbarium of the University of Natal. One good specimen, as far as possible bearing mature reproductive organs, is cited for each magisterial district. Controversial specimens and others with special interest are also included. Attempts were also made to cite specimens from all herbaria from which sheets were borrowed for study.[2]

1. Fimbristylis monostachyos (L.) Hassk., Kern in Blumea 8 (1):160 (1955); Koyama in Journ. Fac. Sci. Univ. Tokyo III 8 (3):117 (1961). *F. monostachya* (L.) Hassk., Pl. Jav. Rar: 61 (1848); Ridl. in Trans. Linn. Soc., Ser. II, Bot. 2:149 (1884); Clarke in Hook. Fl. Brit. Ind. 6:649 (1893) and in Dur. & Schinz, Consp. Fl. Afr. 5:607 (1895); K. Schum. in Engl. Pfl. Ost. Afr: 124 (1895);

---

[1] Too few specimens precluded calculations for some species.

[2] Herbarium abbreviations are as noted in Gordon-Gray, 1965, together with RLCS—Herbarium of International Red Locust Control Service, Abercorn, Zambia, and SGH—Swaziland Government Herbarium, Mbabane, Swaziland.

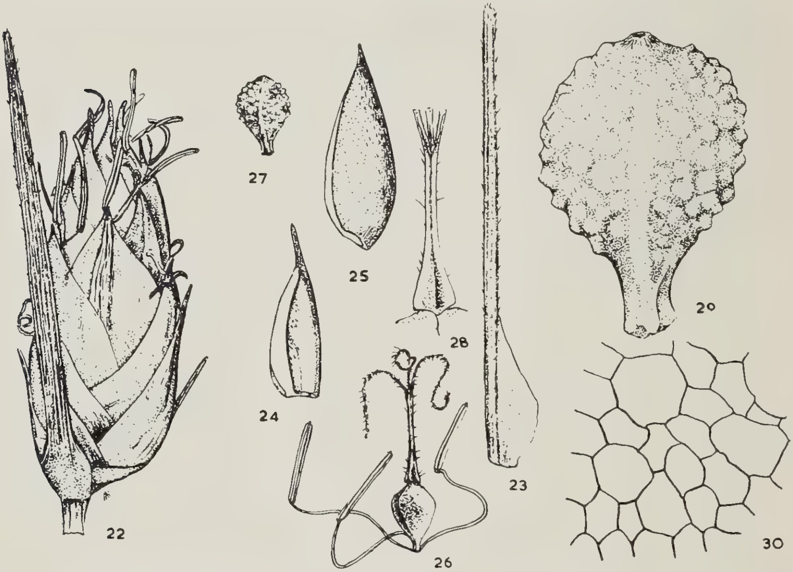
Clarke in Dyer Fl, Cap. 7:203 (1898); Rendle in Cat. Afr. Pl. Welw. 2:122 (1899); Clarke in Dyer Fl. Trop. Afr. 8:424 (1902) and in Bull. Misc. Inf., Add. Ser. 8:109 (1905) name only; Burtt Davy and Leerndertz-Pott in Ann. Tvl. Mus. 3:132 (1912) name only; Phillips in Ann. S.A. Mus. 16:323 (1917); Schonl. in S.A. Cyp., Mem. Bot. Survey S. Afr. 3:34 (1922); de Wild. in Pl, Bequaert 4:206 (1926—7); Dyer in Rec. Albany Mus. 3:470 (1927); Cherm, in Cat. Pl. de Madag. Mem. Acad. Malgache: 32 (1931); Brain in Proc. Rhod. Sc. Assoc. 33:84 (1934); Hutch. in. Fl. W. Trop. Afr. II, 2:474 (1936); Peter in Fedde Rep. 40:402 (1936—7).

Cyperus monostachyos Linn. in Mant. Pl. 2:80 (1771); Rottb. in Descr. et Icon. Pl. :18, t.13, fig. 3 (1773).

Abildgaardia monostachya Vahl in Enum. Pl. 2:296 (1806); Kunth in Enum. Pl. 2:247 (1837); Boeck. in Linnaea 37:53 (1871); Oliv. in Trans. Linn. Soc. 29:169, t.109, fig. a (1875); Bak. in Fl. Maur.: 416 (1877); Robyns & Tournay in Fl. des Sperm. du Parc. Nat. Albert 3:259 (1955).

Perennial, erect, up to 52 cm. in height, tufted: *rhizome* woody, up to 5 mm. wide, of usually slightly swollen shoot bases confluent in uniseriate row or less frequently an irregular tuft; *leaf bases* pale to dark brown, faintly striate, firm to hard, sometimes coarse, forming persistent tunics to shoots except in first year of growth: *leaf sheaths* entire, soon splitting apically, rounded, glabrous, keel faint, green to yellowish, 5-many nerved, membranous zone chartaceous to light brown, with or without darker speckles, faintly many nerved especially basally, mouth truncate; *ligule* 0; *blades* always developed, up to 22 cm. long, 0·5—1·7 (0·85 ± 0·06) mm. wide, linear to almost filiform, firm to stiff, glabrous, margins thickened to ridged, one slightly involute, scabrid pubescent, apex acute to acuminate: *flowering stems* erect, flattened, markedly two-angled below inflorescence, angles scabrid, occasionally smooth, glabrous : *inflorescence* usually a solitary terminal spikelet, occasionally one sessile or pedicelled spikelet added; *pedicel*, when present up to 15 mm. long, as flowering stem; *bracts* 2—3, up to 13 mm. long, infrequently exceeding spikelet, glume-like with keel excurrent forming blade-like apiculus up to 10 mm. or (in upper) mucron 1—2 mm. long : *spikelets* 7—19 (12·35 ± 0·63) mm. long, 3—6 (4·45 ± 0·19) mm. broad, up to 29 mm. in extreme age, compressed in lower half (particularly noticeable when young) almost cylindrical in upper half, ovate to elliptic when young, lanceolate to oblong in age, green to yellowish green when fresh, paling with drying, basal glumes early deciduous; *rachilla* spiralled, winged by rounded, often unequal, pale to darker brown, often speckled glume bases; *glumes* lowest 1—4 sterile, remainder fertile, 5·0—7·5 (6·22 ± 0·15)mm. long, 3·4—5·8 (4·99 ± 0·15) mm. in total width, broadly ovate to ovate oblong, glabrous, keel rounded, of 1—5 yellowish to pallid veins, mid-nerve well marked, excurrent into mucron approximately 1 mm. long, apex acute: *stamens* 3; *anthers* 1·6—3·6 (2·41 ± 0·12) mm. long, cream to light yellow, crest rounded; *style* 2·6—4·6 (3·68 ± 0·12) mm. long including darker brown pyramidal base, 3-winged, wings transparent, delicate, extending on to style base, drying and shrivelling in age, margins white villous; branches 3, concolorous with style base: *achene* 2·0—2·8 (2·35 ± 0·06) mm. long, 1·2—1·9 (1·44 ± 0·05) mm. broad, trigonous, obovate almost pyriform with apex shortly projecting, green when young becoming fawn then white, occasionally pale brown with dark brown of inner pericarp layers discernible, surface reticulate, faintly to prominently tuberculate; *outermost cells to pericarp* subquadrate, velate (loosening of this layer causing eventual white coloration of achene).

Flowering period: Generally September to March, occasionally July to April.



Figs. 22-30 *Fimbristylis monostachyos*, L. Hassk. (Huntley 556)
22—spikelet; 23-4—two basal glumes; 25—fifth glume from spikelet base; 26—young floret; 27—achene (all × 5); 28—style base and style (× 10); 29—achene (× 20); 30—epidermal pericarp cells (× 140).

TYPE: Deposited in Linnaean Herbarium, London. Linnaeus (1771) gives the collector as Koenig and the type locality as "In India Orientali", but it is not known whether the sheet in the Linnaean Herbarium is Koenig's. The type consists of a short portion of rhizome, leaves, and flowering stems, the last named bearing each a solitary spikelet.

CONGO. Without distr: Katanda, *Lebrun* 7554 (NU, BR); Kasonsero, vallee Semliki, *Bequaert* 5065 (BR); Lingila, *Dupuis* s.n. (BR); Broutle, *Binga* s.n (BR); Plaine Rusiri, basin Lushima, *Germain* 6909 (PRE).

UGANDA. Mbara distr: Ankole, *Eggeling* 4867 (EA).

KENYA. Narok distr: Ndunyangero area near Njura settlement, about 9 ml. from Olulunga, *Glover*, *Gwynne* & *Samuel* 1666 (PRE); Nairobi distr: Nairobi Royal National Park, *Verdcourt* 3253 (PRE).

RWANDA. Parc. Nat. Kagera, plaine de Kamabaka, *Germain* 1494 (PRE).

TANZANIA. Bukoba distr: Kagera Port, *Haarer* 2362 (EA); Musoma distr: 46·6 ml. from Bologonja River via Kleins Camp, *Greenway* 10,131 (PRE); N. Kilosa distr: Tembo, *Haarer* 1955 (EA, BR).

ZAMBIA. Luangwa distr: Mt Makulu Pasture Research Station, 9 ml. S. of Lusaka, *Robinson* 1492 (EARO); Batoka distr: Kalomo, *Robinson* 2547 (PRE, NU, EARO).

MOZAMBIQUE. Sabie distr: Namaacha, Sul do Save, *Myre* & *Carvalho* 303 (LM, NU).

RHODESIA. Gwelo distr: Gwelo, *Brain* 7483 (SRGH); Melsetter distr: Melsetter, *Otterson* s.n. (SRGH).

TRANSVAAL. Sibasa distr: Malathlapanga, near Sibasa, *van der Schyff* s.n. (PRE); White River distr: Kruger National Park, Pretorius Kop, *van der Schyff* 2190 (PRE); Rustenburg distr: Rietfontein, *Pole Evans* H18909 (PRE); Brits distr: Hartebeestepoort near Pretoria, *Moss* 8856 (J); Pretoria distr: Pretoria North, *Theiler* s.n. (GRA, PRE); Middelburg distr: 47 ml. from Stofberg on Steelpoort rd., *Meeuse* 10257 (PRE); Belfast distr: Machadodorp, *Galpin* 13013 (BOL, PRE); Barberton distr: 19 ml. from Havelock Mine, Barberton rd., *Gordon-Gray* 6107 (NU); Krugersdorp distr: Magaliesberg, *Zeyher* 1752 (BOL, NBG, PRE); Johannesburg distr: Witwatersrand, Frankenwald, *Gilman* s.n. (J); Benoni distr: near Dunswart, *Moss* 13900 (J); Carolina distr: Carolina, *Rademacher* s.n. (PRE); Ermelo distr: Amsterdam, Athole Pasture Research Station, *Norval* 145 (PRE); Potchefstroom distr: Boskop, *Louw* 583 (PUC, PRE, PRU); Vereeniging distr: Vereeniging, Burttholm, *Burtt Davy* 15204 (GRA, J); Heidelberg distr: Uitgevallen, *Burtt Davy* 9168 (PRE); Standerton distr: Standerton Govt. Farm, *Burtt Davy* 921 (PRE, BOL); Wakkerstroom distr: Wakkerstroom, Beeton 139 (NBG); Piet Retief distr: Piet Retief, *Leipoldt* s.n. (GRA, PRE);

SWAZILAND. Mbabane distr: Komati Pass, *Compton* 31046 (SGH); Hlatikulu distr: Hlatikulu, *Gordon-Gray* 6170 (NU).

ORANGE FREE STATE. Heilbron distr: Heilbron, *Goossens* 502 (PRE, BLFU);

Senekal distr: upper slopes Doornkop Groot, *Goossens* 914 (PRE, PUC); Bethlehem distr: Golden Gate National Park, *Liebenberg* 6810 (PRE); Thaba Nchu distr: lower n. slopes Thaba Nchu mt., *Roberts* 2946 (PRE).

NATAL. Vryheid distr: Hlobane, *Johnstone* 324 (NU); Ubombo distr: Mkuze Game Reserve, *Ward* 3534 (NPGF, NU); Dundee distr: Dundee, Townlands, *Shirley* s.n. (NU); Helpmekaar distr: Helpmekaar *Kleber* s.n. (NU); Nongoma distr: 30 ml. from Mkuze on Nongoma rd., *Gordon-Gray* 4721 (NU); Hlabisa distr: Hluhluwe Game Reserve, *Ward* 2096 (NU, NPGF, BR); Estcourt distr: Umhlumba Mt., *West* 1484 (NH); Lower Umfolozi distr: Umfolozi Game Reserve, *Feely* 86 (NPGF, NU); Eshowe distr: Tugela Weir above Mandini, *Edwards* 1599 (PRE, NU); Mtunzini distr: Mtunzini, *Mogg* 4513 (PRE); do., "Hamewith", *Mogg* 5925 (PRE, SRGH, GRA); do., *Mogg* 6033 (GRA); Lions River distr: Lidgetton, *Mogg* 835 (SRGH, PRE); Pietermaritzburg distr: Pietermaritzburg, Alexandra Park, *Huntley* 539 (K, NU); Inanda distr: near Phoenix, *Wood* 4918 (BOL, NBG, PRE, NH); Camperdown distr: Nagle Dam, *Wells* 1665 (NU); Pinetown distr: Mariannhill, below and behind hospital, *Bayer* s.n. (NU); Durban distr: Isipingo North, *Ward* 556 (K, M, NU); Umzinto distr: Hibberdene, *Bayer* s.n. (NU); Alfred distr: Harding, Bedford Farm, *Lennox* s.n. (NU); Port Shepstone distr: Port Edward, *Huntley* 715 (NU).

BASUTOLAND. Leribe distr: Leribe, *Dieterlen* 549 (NBG, NH, PRE); Maseru distr: Roma, *Ruch* 2374 (PRE).

CAPE PROVINCE. Umzimkulu distr: Umzimkulu, *Tyson* 2868 (NBG); Umtata distr: between Gekau and Bashee R., *Drége* s.n. (NBG); Queenstown distr: Queenstown mts., Fincham's Nek, Galpin 2548 (BOL, GRA, PRE); Elliotdale distr: Tembuland, between Bashee R. and Morley, *Drége* s.n. (K); Willowvale distr: Willowvale, Qora R. mouth, *Hilner* 461 (GRA); Stutterheim distr: Dohne Research Station, *Acocks* 9266 (PRE); Kentani distr: Kentani, *Pegler* 1096 (GRA, BOL); Komgha distr: near Komgha, *Flanagan* 914 (PRE, GRA, BOL); Victoria East distr: Lovedale, Blackhill, *Barker* 2778 (NBG); Kingwilliamstown distr: Kingwilliamstown, e. slopes above cemetery, *Hilner* 105 (GRA); East London distr: East London, *Rattray* 815 (GRA); Albany distr: Grahamstown, *MacOwan* 188 (BOL, GRA, NH).

In Africa the species also occurs in Angola (*Rendle*, 1899) and West Tropical Africa, (*Hutchinson*, 1936) but no specimens from these localities have been seen.

WORLD DISTRIBUTION. The species is also known from Malagasy, Mauritius, India, Malaysia, Southern Asia, Australia, Polynesia, Temperate and Tropical America.

Kern (1955) corrected the orthographic error made by Hasskaal (1848). *Fimbristylis*, by its ending and common usage is feminine. In agreement the epithet, of Greek derivation, must take the ending "os" not "a".

In Southern Africa, on the Natal coast in particular, marked variation in robustness of plants growing in juxtaposition is frequent. Specimens with broad, coarse leaf bases, blades approximately 1·5 mm. in width and stout flowering stems occur beside more slender plants, often equally tall, but with finer, softer leaf bases and blades 0·5—0·7 mm. in width. Huntley 715, and Mogg 6033, 4513, 5925, illustrate such variation.

Fimbristylis monostachyos is a ubiquitous associate of grasses in the thornveld and savannah regions of eastern Southern Africa, flourishing particularly where the grass cover is sparse and competition with taller plants not too severe. Apparently without soil preference, it occurs in sand, shale or clay, in black turf of vleis, or in soil pockets amongst rocks.

2. Fimbristylis triflora (L.) K. Schum. ex Engl. in Abh. Preuss Akad. Wiss: 14 (1894) and in Engl. Pfl. Ost. Afr: 124 (1895); Turrill in Kew Bull. 1925: 71 (1926); Hutch. in Fl. W. Trop. Afr. II, 2:476 (1936); Peter in Fedde Rep. 40:402 (1936—7); Podlech in Mitt. der Bot. Staatss., Munchen, 3:528 (1960).

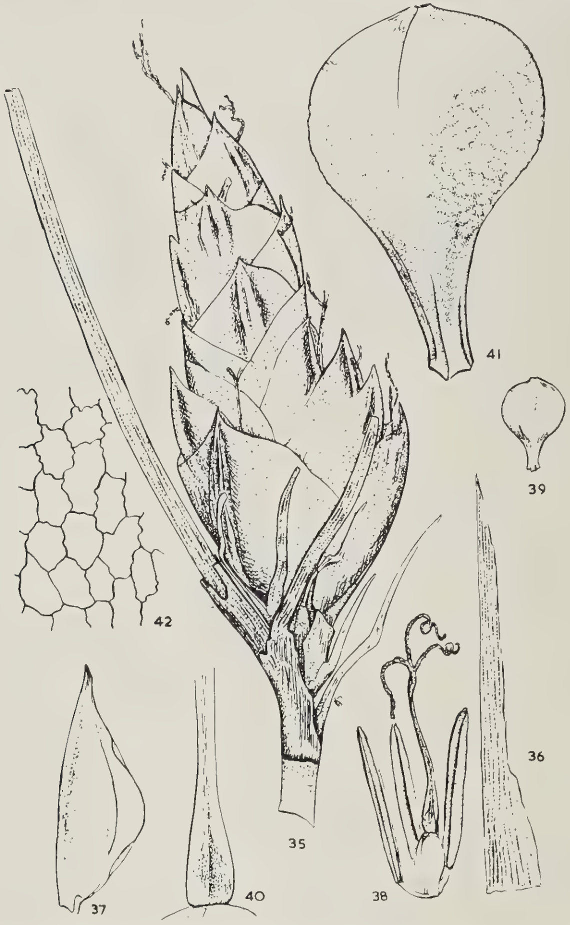
Cyperus triflorus Linn. in Mant. Pl. 2:80 (1771).

Abildgaardia tristachya Vahl in Enum. Pl. 2:297 (1806); Nees in Linnaea 9:289 (1834) name only; Kunth in Enum. Pl. 2:248 (1837); Boeck. in Linnaea 37:54 (1871).

Fimbristylis tristachya Thwaits in Enum. Pl. Zeyl: 434 (1864) non R. Br. non Nees; Clarke in Fl. Brit. Ind. 6:649 (1893) and in Dur. and Schinz., Consp. Fl. Afr. 5:610 (1895) and in Dyer Fl. Trop. Afr. 8:424 (1902) and in Bull. Misc. Inf., Addit. Ser. 8:109 (1908) name only, and in Illustr. Cyper. t 43. f. 12—14 (1909).

Abildgaardia lanceolata Schumach in Beskr. Guin. Pl. :33 (1827). *A. monostachya* Vahl var. Hassk. in Pl. Jav. Rar.: 61 (1848).

Perennial, erect, up to 91 cm. in height (40—70 usual for Southern African examples) tufted: *rhizome* up to 9 mm. wide, *leaf bases* dark brown to black, striate, sometimes slightly polished, firm to hard, coarse, forming well marked persistent tunics to shoots, except in first year of growth; *sheath mouth* truncate, occasionally sloping and oblique; *blades* always developed, up to 40 cm. long (30 cm. usual for Southern African specimens) 1·0—2·0 mm. wide, linear, stiff, glabrous; *inflorescence* variable, up to 5·5 cm. long, up to 7 cm. wide, usually a simple "umbel" (anthela) of one central sessile and 1—4 pedicelled spikelets, occasionally of central sessile spikelet only (all possibilities may be represented on a single plant) pedicels up to 3 cm. long; *bracts* 2—4, up to 2 cm. long: *spikelets* 11—22 mm. long, sometimes 32 mm. in extreme age, 4—7 mm. wide, greenish yellow when fresh, pallid to yellowish when dry; fertile *glumes* 5·8—9·3 mm. long, 3·2—6·1 mm. in total width, keel of 1—11 pallid to brownish veins: *anthers* 2·9—4·1 mm. long: *style* 4·5—5·5 mm. long including long pyramidal style base that becomes dark brown in age, faintly 3-winged when young to 3-angled at maturity: *achene* 2·3—3·1 mm. long, 1·5—1·9 mm. broad, obovate to markedly pyriform, apex shortly projecting,



Figs. 35-42 *Fimbristylis triflora* (L.) K. Schum. (Ward 2831)
35—spikelet; 36—basal glume; 37—fifth glume from spikelet base; 38—young floret; 39—achene (all × 5); 40—style base and style (× 10); 41—achene (× 20); 42—epidermal pericarp cells (× 140).

green when young, becoming fawn to dark brown, eventually almost black, shining, occasionally pallid to off-white; surface reticulate, etuberculate to prominently tuberculate; *outermost cells to pericarp* subquadrate, eventually velate. Otherwise as *F. monostachyos*, including flowering period and remarks relating to type and type locality. The type consists of inflorescences and flowering stems only. No vegetative organs are present.

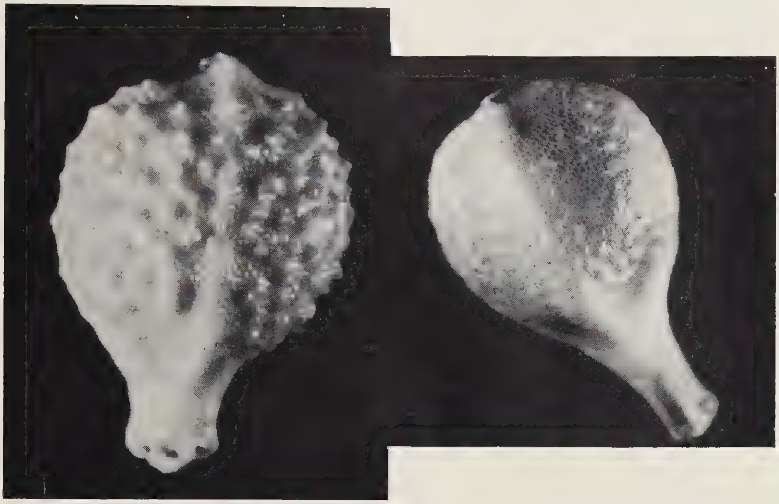


Fig. 43 Mature achenes: left—*F. monostachyos* (× 30); right—*F. triflora* (× 20).

GHANA. Nungua distr: *Ankrah* s.n. (PRE).

TOGOLAND. Near Lome, *Warneke* 140 (EA).

TANZANIA. Tanga distr: Tanga Bay, *Greenway* 1859 (EA); Pemba, Tondooni, *Greenway* 1426 (EA); Pangani distr: am Pangani bei Korogwe, *Peter* 3862 (EA); Zanzibar, Kasoli, *Tait* 19 (NU); Zanzibar, without precise locality, *Tait* 30 (NU).

ZAMBIA. Babemba distr: Lushiba Bay System: n.e. Lake Mweru, *H.D.B.* 523 (RLCS); Batoka distr: Muckle Neuk, 12 ml. n. of Choma, *Robinson* 445 (EARO).

MOZAMBIQUE. Zambesia, Chinde distr: Micaune, S.A. Medal Estates, Nuanaiu, *Pedro* 27 (PRE); Buzi distr: Beira, *Rogers* 104564 (NGB, BUL); Sofala distr: Manica e Sofala, Mucarangue, *Lea* 80 (PRE).

SOUTH WEST AFRICA. Okavango Native Territory, 4 ml. e. of Masari Expt.

Farm on road to Nyangana, *de Winter* & *Wiss* 4108 (PRE, M); E. Caprivi, Zipfel, *Killick* & *Leistner* 3045 (PRE).

Rhodesia. Sebungwe distr: Chikwatata Hot Springs, Bingo, *Phipps* 1393 (SRGH, PRE).

Transvaal. White River distr: Pretorius Kop, *van der Schyff* 3376 (PRE).

Natal. Ubombo distr: Nibela, *Ward* 1706, 1708 (NU); Hlabisa distr: St Lucia Park, n. of Mpate R., *Ward* 4505 (PRE, NPGF, NU); Mtunzini distr: Mtunzini, "Hamewith", *Mogg* 5811 (K) (holotype var. *capitata* Turrill), do., 5865 (PRE, GRA).

World Distribution. The species is also known from India.

In Southern Africa, *Fimbristylis triflora* occurs amongst grasses in marshes, temporary swamps and on seasonally inundated flats. As far as is known at present it is limited to sandy soils.

Discussion

F. triflora may be described as a more robust state of *F. monostachyos*. Nevertheless there are morphological differences, albeit slight and of degree rather than absolute in character, which, when considered collectively and in conjunction with differing ecological preferences indicate discontinuity between the taxa. These differential characters (White, 1962) are summarised in Table 1. Most reliable features are printed in italics.

Table 1

Morphological differences between *F. monostachyos* and *F. triflora*

F. monostachyos	*F. triflora*
Plants bearing mature achenes up to 55, *generally* 10—30, cm. in height.	Plants bearing mature achenes up to 95, *generally* 40—75, cm. in height.
Leaf bases clothing rhizome pale to dark brown, fine to coarse, forming conspicuous persistent tunics to shoots only when sheaths coarse.	Leaf bases clothing rhizome dark brown to black, slightly polished, always coarse, forming dark colored persistent tunics to shoots.
Leaf blades 0·5—1·7 mm. wide, sometimes almost filiform, otherwise linear.	Leaf blades 1·0—2·0 mm. wide, linear, rather coarse and stiff.
Inflorescence a solitary terminal spikelet; occasionally an "umbel" (anthela) of terminal spikelet with 1—2 pedicelled spikelets added; rarely a head of 2 sessile spikelets.	*Inflorescence an "umbel" (anthela) of one terminal sessile spikelet with 1—4 pedicelled spikelets added;* occasionally of solitary terminal spikelet only; rarely a head of 2 (or more) sessile spikelets.
Living spikelets green to yellowish-green, paler when dry.	*Living spikelets greenish-yellow, pallid to yellowish when dry.*
Achene, even when fully matured on plant, not shining black (all degrees of coloration from white to dark brown common, white predominating).	Achene, when fully matured on plant, shining black (all degrees of coloration from off-white to dark brown common, pale brown predominating).

The close relationship between these two species is worthy of discussion, for it reflects very well the situation often encountered within Scirpeae, particularly when world taxa are under consideration, for pairs or groups of species often show very close morphological similarity. *All* individual points of difference between *F. monostachyos* and *F. triflora* occasionally break down. For example, the inflorescence in the former is generally a solitary spikelet, in the latter a simple "umbel" of 1 sessile and 1—4 pedicelled spikelets. However, plants of *F. monostachyos* sometimes bear simple "umbels" of 1 sessile and 1—2 pedicelled spikelets, while plants of *F. triflora*, particularly at their southerly limit of distribution in Africa, may bear only solitary spikelets. Such plants are usually infrequent within the population, so in the field, where habitat conditions may also be assessed, confusion can be avoided. In the herbarium such plants are disconcerting, especially so when more than one unusual morphological feature is represented in an individual.

Achene colour (Clarke, 1902) has also been relied upon in diagnosis, but is unsatisfactory because of changes during maturation. If matured on the plant, fertile achenes of *F. triflora* are eventually shining black due to pigmentation of sclerenchyma underlying the large outermost epidermal pericarp cells that peel, effectively exposing the dark tissue. Most achenes are shed before this stage is reached. Some remaining attached to the spikelet do not develop fully, probably due to failure of fertilization, and so lack this coloration. Shining black achenes have never been observed for *F. monostachyos*, but light to dark brown pigmentation of pericarp sclerenchyma is not unusual.

Many achenes of *F. triflora* are more markedly pyriform, even spatulate, than are those of *F. monostachyos* (see Fig. 43), but too many exceptions exist for the character to have real value in diagnosis. The faint tuberculations evident in the achene of *F. triflora* (see Fig. 43) are sometimes entirely lacking, frequently as prominently marked, as in the achene of *F. monostachyos* (see Fig. 43). Examination of large numbers of achenes of both species laid side by side has shown them to be often indistinguishable in size, shape, colour and markings.

Despite the lack of obvious morphological discontinuity between the species, for even collective consideration of all differential characters sometimes allows of doubt in diagnosis, both species must be maintained, for ecological preferences differ, as does distribution. In tropical regions *F. monostachyos* retains its relatively low stature and appears to favour grassland habitats at higher altitudes, while plants of *F. triflora* become very tall and mostly favour coastal areas, vleis or other seasonally inundated, relatively lower lying regions.

Hybridisation would seem an obvious possible explanation for close morphological relationship, but where the species are sympatric, no putative hybrids have been detected, possibly because such areas fail to provide habitats intermediate between the differing environments favoured by *F. monostachyos* and *F. triflora.*

Chromosome studies, stomatal measurements and artificial hybridisation might provide information of significance in further elucidating relationships

Turrill (1925) established within *F. triflora*, variety *capitata* (holotype Mogg 5811, K), that was distinguished from the type by the spikelets of the flowering stem all being sessile and clustered into a compact head. Field study has shown this is only occasional on a plant and that "umbels" may be produced by the same plant in the same season. Similar compact heads have occasionally been observed within *F. monostachyos* (Burtt Davy 15204, Hilner 105, Mogg 4513). Consequently Turrill's variety is not maintained.

REFERENCES

CLARKE, C. B., 1902. Cyperaceae. *In* Thiselton-Dyer, W.T., Fl. Trop. Afr. **VIII**: 413.

GORDON-GRAY, K. D., 1965. Studies in Cyperaceae in Southern Africa: III, Two new species of *Fimbristylis* Vahl: Journ. S. Afr. Bot. **32,** 1: 129—140.

HUTCHINSON, J., 1936. Cyperaceae. *In* Hutchinson, J. and Dalziel, J. M., Fl. West Trop. Afr. **II,** 2: 476.

KERN, J. H., 1955. Florae Malesianae Precursores X. Notes on Malaysian and some S.E. Asian Cyperaceae. Blumea **VIII,** 1: 158—161.

KOYAMA, T., 1961. Classification of the Family Cyperaceae (1). *In* Journ. Fac. Sci. Univ. Tokyo, **III,** 8 **(3)**: 99—101.

RENDLE, A. B., 1899. Catalogue of Welwitsch's African Plants **II,** 1: 122.

TURRILL, W. B., 1926. Notes on Cyperaceae II. *In* Kew Bull. 1925: 71.

WHITE, F., 1962. Geographic Variation and Speciation in Africa with Particular Reference to *Diospyros. In* Taxonomy and Geography **IV**: 71—103.

STUDIES IN STREPTOCARPUS II:
THE STREPTOCARPUS GRANDIS ALLIANCE

O. M. Hilliard
(*Bews Botanical Laboratories, University of Natal, Pietermaritzburg*)

Six, or possibly seven, species, largely confined to Natal, but having close affinity with certain Tropical African species, comprise the alliance. *S. grandis* occurs throughout the forests of Zululand and the Natal Midlands, and shows considerable variation in corolla size and colouring and, to a lesser degree, in corolla shape. Its closest ally in Southern Africa is *S. cooperi* with a limited distribution range from Qudeni across the Biggarsberg to the Drakensberg at Colling's Pass and Van Reenen. *S. wendlandii* is apparently endemic in Ngoye forest and is closely related to *S. molweniensis* which is known only from kloof forests in the environs of Durban. Anomalous populations in the forests around Eshowe have affinity with these two species. *S. saundersii* is confined to coastal forests north of Durban. It is probably allied to *S. breviflos*, based on a single specimen collected by Cooper in the Orange Free State. Although Burtt (1939) reduced *S. breviflos* to synonymy with *S. saundersii*, it is preferable to maintain it provisionally as an insufficiently known species. *S. porphyrostachys*, a very distinctive species from the Umtamvuna gorge near Port Edward, has hitherto escaped notice. Its corolla and gynoecial characters advocate its inclusion in this alliance.

The alliance is circumscribed by a number of correlated morphological characters. The corolla tube is subcylindric, cylindric or narrowly infundibuliform, generally long in relation to breadth and with a cylindric mouth. Certain gynoecial characters are associated with this corolla form. The style is terete, sometimes slightly dorso-ventrally compressed apically, and shorter than the ovary; the stigma is stomatomorphic and papillose; the capsule is long and relatively slender with an inconspicuous style base.

There are striking similarities in the patterning on the floor of the corolla tube and on the lower lip in all taxa within the alliance. Vascular strands run along the floor and walls of the tube and arc out into the lobes of the lower lip, where they anastomose, thus demarcating a number of narrowly wedge-shaped, and often slightly bullate, islands of tissue. Each vein may or may not be marked by a violet line. The two most conspicuous wedges lie along the floor of the tube and continue down the centre of the anterior lobe. Two, sometimes three or four, smaller wedges are distinguishable in each lateral lobe. In the mouth of the tube, the tissue on either side of the median wedges is deep violet. The lateral wedges are invariably white though, naturally, in pale colour forms of *S. grandis* and *S. saundersii* this is obscure. The median wedges are white in *S. cooperi*, *S. wendlandii*, *S. molweniensis*, *S. porphyrostachys* and the Eshowe taxon; white, sometimes yellow, occasionally reddish in *S. grandis*; always yellow in *S. saundersii*. Although the colour of the median wedges may vary, the overall pattern is identical. Lawrence (1957), on investigating the genetics of flower pattern in *Streptocarpus*, found that "species which have been classified into groups on gross morphological criteria are found to be characterised also by their genotypes for flower pattern". Of the species under discussion, Lawrence studied only *S. grandis* and *S. wendlandii*, which he found to possess the same supergene governing flower pattern.

It is logical to conclude that there is a genotypic basis for the similarity in corolla pattern among all members of this alliance.

These species are all forest plants. With the exception of *S. porphyrostachys*, they are solitary-leaved and therefore monocarpic. The leaf can grow very big, probably in response to low light intensities in forest. Other monocarpic species, typified by *S. cooksonii*, which favour rock outcrops generally have smaller, thicker leaves than the forest dwellers, an expected response to the drier conditions and more intense illumination of exposed habitats.

General characteristics

Stemless, generally monocarpic, but one species perennial, terrestrial or epiphytic herbs. *Leaf* 1, pilose or scabridulous (rough to the touch), base cordate or obtuse, apex usually withered, upper surface rugulose, veins impressed above, prominent below. *Inflorescences* cymose, several in acropetal succession from upper surface near base of midrib. *Calyx* 5-partite. *Corolla* bilabiate, *tube subcylindric, cylindric or narrowly infundibuliform*, deflexed about the middle or almost straight, *cylindric in throat*; limb straight or slightly oblique, upper lip 2-lobed, lower lip 3-lobed. *Stamens*: fertile 2, included, epipetalous; anthers bilobed, applanate; staminodes 3, posterior minute, laterals filiform, not exceedng 8 mm. long. *Disc* annular. *Ovary* terete; *style* terete, sometimes slightly dorsoventrally compressed, shorter than ovary; *stigma* stomatomorphic, papillose. *Capsule* relatively long and slender, *persistent style base* inconspicuous.

Key to the species and anomalous populations

1a.	Ovary indumentum patent	2.	
1b.	Ovary indumentum appressed	3.	
2a.	Flower up to 45 mm. long, lower lip 8—15 mm. long, throat c. 10 mm. across		1. *S. grandis*
2b.	Flower 55—70 mm. long, lower lip 18—23 mm. long, throat c. 18 mm. across		2. *S. cooperi*
3a.	Corolla tube widening gradually or abruptly upwards ..	4.	
3b.	Corolla tube approximately the same diameter throughout its length	6.	
4a.	Corolla tube subcylindric below, almost ventricose apically; base of leaf obtuse		6. *S. porphyrostachys*
4b.	Corolla tube narrowly infundibuliform; base of leaf cordate..	5.	
5a.	Corolla tube c. 6 mm. in diam. at base, c. 9 mm. across in throat; yellow stripe on floor of tube..		3. *S. saundersii*
5b.	Corolla tube c. 3 mm. in diam. at base, c. 6 mm. across in throat; no yellow stripe on floor of tube		3. Anomalous Kingscliffe population
6a.	Corolla tube c. 18 mm. long, lower lip c. 22 mm. long; hypocotyl strongly developed, undersurface of leaf beetroot red.		5. *S. wendlandii*
6b.	Corolla tube c. 21—26 mm. long, lower lip c. 12—18 mm. long; hypocotyl not always developed, undersurface of leaf usually green, sometimes red or suffused red	7.	
7a.	Corolla tube c. 21 mm. long, lower lip c. 12 mm. long; capsule 69—119 (92 ± 12) mm. long		4. *S. molweniensis*
7b.	Corolla tube c. 26 mm. long, lower lip c. 18 mm. long; capsule 48—83 (65 ± 8) mm. long		5. Anomalous Eshowe populations.

1. S. grandis N.E. Br. in Bot. Mag. t. 8042 (1905)*; Tracy Hubbard in Bailey, Std. Cyclopedia Hort. 3:3274 (1937); Burtt in Kew Bull: 71 (1939) *et* in R.H.S. Dict. Gard. ed. 2, 4:2044 (1956). (Fl. Pl. S. Afr. t. 803 is discussed under *S. wendlandii*).

Cultivated specimen Hort. Bot. Reg., K, and ex Hort. Walter Ledger, K, SYNTYPES, being designated "type" in N. E. Brown's hand and annotated "originally collected in Zululand by W. J. Haygarth."

S. tubiflos C.B. Cl. in Dyer, Fl. Cap. 4(2): 441 (1904) pp. quoad spec. Gerrardianum.

Monocarpic. *Leaf* up to 380 x 330 mm., pilose, base deeply cordate, upper surface light green, lower paler, hypocotyl occasionally well developed. *Inflorescence* many flowers expanded simultaneously. *Peduncle* up to 400 mm. long, purplish-brown, pilose with glandular and eglandular hairs. *Bracts* lanceolate to linear, up to 8 x 2·5 mm., occasionally foliose, green. *Flower* 30—45 mm. long. *Pedicel* 10—17 mm. long, elongating slightly in fruit, green, pilose with glandular and eglandular hairs. *Calyx* lobes linear, 5 x 1 mm., greenish-brown, pilose, sometimes glandular. *Corolla* tube sub-cylindric to narrowly infundibuliform, slightly deflexed about the middle, medium to pale violet, pilose with patent eglandular and sometimes glandular hairs, 15—30 mm. long, base 4·5 mm. diam., throat c. 10 mm. across; upper lobes divergent, suborbicular, c. 5—6 × 5—6 mm.; lower lip 8—15 mm. long, lobes suborbicular, 4—7 × 4—7 mm.; all lobes white to medium violet, glabrous inside, paler, pilose with glandular and eglandular hairs outside; throat and base of lower lip deeper violet marked with four white wedges, often absent in pale forms, or replaced by a yellow stripe on floor of tube. *Stamens*: filaments inserted two-thirds up corolla tube, 4 mm. long, white, curved, curve dilated, sometimes purplish; anther lobes 2 mm. long, white; *Ovary* 14—20 mm. long, pale yellow suffused purple, pilose with patent eglandular and sometimes glandular hairs; style 6—8 mm. long, white, glandular. *Capsule* 65—111 (93 ± 10) mm. long, 1·2 mm. diam.

Flowering period: October to March.

NATAL. Utrecht dist., Tweekloof, *Thode* A 383, PRE, Ngotshe dist., Ngome forest, *Codd* 9594, PRE, do., c. 1060 m., *Hilliard* 864, E, K, NU; do., *Hilliard* 932 NU; SE Ngome, *Codd* 9599, PRE; near Ngome police station, *Acocks* 13947, PRE; Ingome (Ngome) *Gerrard and M'Ken* 191, K, TCD (cited by Clarke (1883) as *S. cooperi* and (1904) as *S. tubiflos*). Nongoma dist., near the windmill of the R.C. Mission, *Gerstner* 4691, PRE. Nkandla dist., Sebundini (Isibundini), *Haygarth* s.n. in herb. *Wood* 7465, NH (non K); Nkandla forest, 1220 m., *Hilliard* 821, E, K, NBG, NH, NU, do., *Lawn* 494, NH, do., *Codd* 6965, NH, PRE, do., *Codd* 9690, PRE, do., *Gerstner* 3218, PRE; 16 mls. S. Nkandla, *Reynolds*, 3226, 3228, PRE. Umvoti dist., near Ahrens, farm "Mowbray", 1050 m., *Hilliard* 1149, NU; Eshowe dist. near Eshowe, farm "Croisdale", c. 600 m., *Hilliard* 1175, NU; near Eshowe, Matchstick Hill, margin Ngotshe forest, c. 600 m., *Hilliard* 873, NU. Mtunzini dist., Ngoye forest, c. 275 m., *Hilliard* 2708, NU. Lions River dist., Karkloof, Blinkwater Bush, *Hilliard* 825, NU; Karkloof, farm "The Start", 1067 m., *Hilliard* 1210, NU. Pietermaritzburg dist., Chase Valley, 975 m., *Hilliard* 1151, NU; Swartkop, c. 1060 m., *Hilliard* 826, NU; Town Bush Valley, 975 m., *Hilliard* 856, E, NBG, NU; Table Mt., *Killick* 370, NU; Chase Valley, *v/d Merwe* 2628, PRE; Allterton *Mogg* 6573, PRE; Winterskloof, *F.G.C.* 491, J. Richmond dist., farm "Osgodsby", 1140 m., *Hilliard* 855, E, K, NU. Ixopo dist., Qunu Falls, 1036—1128 m., *Hilliard* 1150, NU.

Brown (1905) described *S. grandis* from cultivated specimens but his statement that "the species was discovered in Zululand together with *S. haygarthii*" pinpoints the type locality as Nkandla forest, because that is the type locality of *S. haygarthii*. That the plants were growing actually together is substantiated by the fact that the gatherings were mixed and Clarke (1904) mistakenly described the leaf of *S. grandis* as that of *S. haygarthii*, to which error Brown drew attention.

The type sheet of *S. reynoldsii*, a synonym of *S. haygarthii*, and a sheet of of *S. grandis* bear consecutive collector's numbers, indicating that Reynolds, like Haygarth forty years before him, found both species growing together, and indeed, to this day, there are sympatric populations in Nkandla forest.

S. grandis is common in Zululand forests and extends southwards through the Natal Midlands forests at altitudes of between 600 and 1200 m. (Fig. 1). It has not been recorded from the Transvaal nor from Swaziland, but it is allied to *S. solenanthus* from Tropical Africa. Like *S. solenanthus*, *S. grandis* is extremely variable in corolla colour and markings and, to a lesser degree, in corolla shape and size.

Every population of *S. grandis* is slightly different from every other population. Nkandla specimens have a narrowly infundibuliform corolla tube, which elsewhere tends towards subcylindric. (Fig. 2). Colour varies from pure white to violet, or pink, sometimes with stripes or suffusions of deeper colour on a light or white ground. A yellow streak on the floor of the tube may or may not be present.

In Nkandla forest, the shape of the corolla is constant, but the colour varies from pale to deep violet, very occasionally pink, and there is slight variation in corolla size. In the bush patches en route to Lilani, near Greytown, the corolla is often pink, or striped violet on a paler ground. Populations in Ngome forest have the largest flowers so far seen, with corolla colour varying from pale to deep violet. The floor of the corolla tube is usually deep violet longitudinally divided by a white streak, sometimes replaced by a yellow or reddish-purple one. This variation is seen in plants growing side by side. A pale yellow streak on the floor of the tube is sometimes seen in specimens from Town Bush Valley and Swartkop, Pietermaritzburg. The presence or absence of a yellow streak is interesting in view of the opinion of W. J. C. Lawrence, an authority on the genetics of the genus, quoted by Burtt and Sealy (1946) as saying that "in his experience the yellow streak is of definite diagnostic value, and that it is either present . . . or entirely absent—the distinction is absolute."

Despite its variability, *S. grandis* is not easily confused with other species. Affinity is with *S. cooperi*, the floral resemblance between *S. cooperi* and the Nkandla form of *S. grandis* being so strong that virtually corolla size alone serves to distinguish the two species. The corolla of *S. grandis* is less than 45 mm. long, that of *S. cooperi* is about 70 mm. long. Furthermore, *S. grandis* flowers in late spring, *S. cooperi* in late summer. Although Qudeni and Nkandla forests are only about ten miles apart, separated by the valley of the Nsuze

Studies in Streptocarpus
II. The S. grandis Alliance

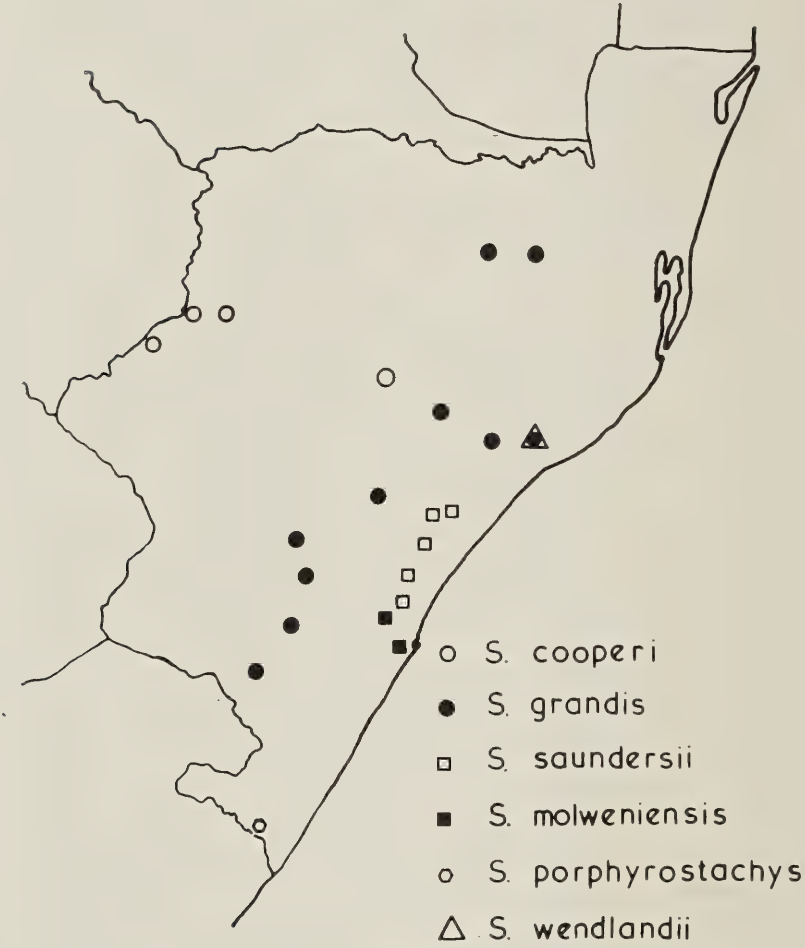


FIG. 1.
Map of Natal showing distribution of *S. grandis* and its allies.

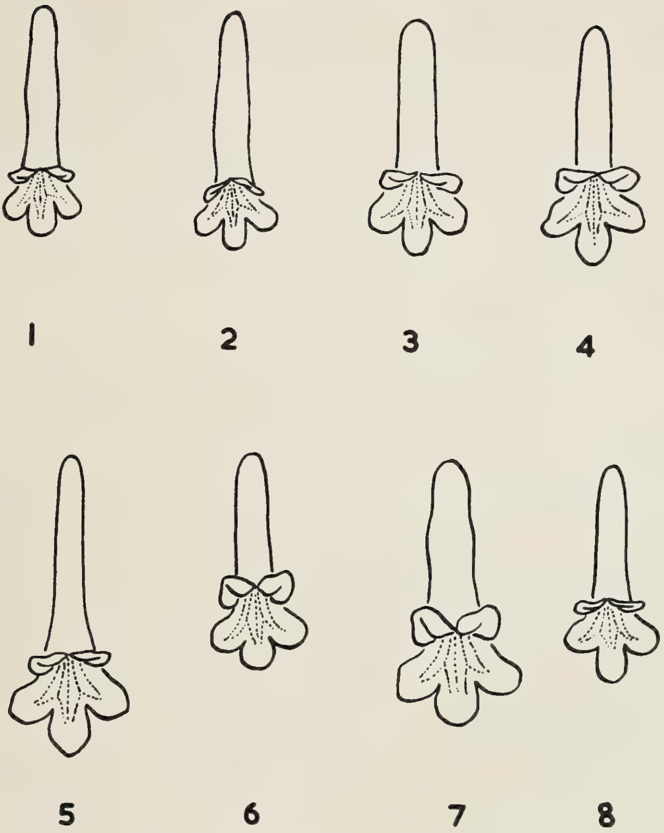


FIG. 2.
Corolla variation in *S. grandis*.

1. Town Bush Valley, Pietermaritzburg.
2. Swartkop, Pietermaritzburg.
3. Mapumulo.
4. Lilani.
5. Nkandla Forest.
6. "Croisdale" near Eshowe.
7. Ngome Forest.
8. "Osgodsby" near Richmond.

(diagrams about natural size)

river, *S. grandis*, common in Nkandla forest, is not found at Qudeni, and *S. cooperi*, common in Qudeni forest, is not found at Nkandla.

Both species have very long capsules (generally 100 mm. or more) and a patent indumentum on the ovary. These two characters readily distinguish them from *S. saundersii*, *S. wendlandii*, *S. molweniensis* and *S. porphyrostachys*, all of which have appressed pubescent ovaries, and, except *S. molweniensis*, appreciably shorter capsules.

Occasional interspecific hybrids occur in sympatric species populations. At World's View (Pietermaritzburg), *S. gardenii* is common on a tumble of mossy rocks in forest; *S. grandis* is found on steep earth banks above the rocks. One obvious intermediate between the two species was seen on a tree trunk (legit E. Moll, *Hilliard* 2125, NU). Hybrids between *S. grandis* and *S. haygarthii* are occasional in Nkandla forest (*Hilliard* 2667, NU) and between *S. grandis* and *S. confusus* in outliers of Ngome forest (*Hilliard* 931, NU).

2. S. cooperi C.B.Cl. in DC. Monog. Phan. 5:150 (1883) and in Dyer, Fl. Cap. 4(2):442 (1904).

Clarke (1883) originally cited three specimens under this name: O.F.S. but without precise locality, *Cooper* 1033; Zululand, Ingoma, *Gerrard* 191; Zambezi region, *Buchanan* 99. *Buchanan* 99, K, is *S. goetzii* Engl. (Burtt, 1939); *Gerrard* 191, K, TCD, is *S. grandis* N.E. Br.; *Cooper* 1033, K, is therefore proposed LECTOTYPE of *S. cooperi*, BM, E, TCD, ISOLECTOTYPES.

Monocarpic. *Leaf* up to 700 x 700 mm., pilose, base deeply cordate, upper surface medium green, lower paler. *Inflorescence* many flowers expanded simultaneously. *Peduncle* up to 500 mm. long, green, pilose, with glandular and eglandular hairs. *Bracts* elliptic, up to 30 × 10 mm., green, pilose. *Flower* 55—70 mm. long. *Pedicel* 15—20 mm. long, elongating in fruit, green, glandular, sparsely pilose. *Calyx* lobes lanceolate, 9 × 2 mm., green, glandular, sparsely pilose. *Corolla* tube narrowly infundibuliform, slightly saccate below near apex, medium violet, glandular, sparsely pilose, up to 45 mm. long, base 5·5 mm. diam., throat c. 18 mm. across; upper lobes divergent, suborbicular, 12 × 15 mm.; lower lip 18—23 mm. long, lobes elliptic-oblong, 12 × 9 mm.; all lobes medium violet, glabrous inside, paler, glandular outside, mouth glandular, floor of tube and base of lower lip rich violet-purple marked with four white wedges. *Stamens*: filaments inserted two-thirds up corolla tube, 9 mm. long, white, curved, curve dilated; anther lobes 3 mm. long, white suffused pale violet. *Ovary* 30 mm. long, yellowish, with patent glandular and eglandular hairs; style 8 mm. long, slightly dorsoventrally compressed apically, glandular-pilose. *Capsule* up to 150 mm. long, 2 mm. diam.

Flowering period: January to April.

NATAL: Bergville dist., Van Reenen's Pass, c. 1500 m., *Thode* 3296, STE, do., *Wood* 5704, K, NH. Klip River dist., Cundy Cleugh, 1630 m., *Hilliard* 1233, NU; Colling's Pass, 1676 m., *Hilliard* 1207, NU, Nkandla dist., Qudeni, 1067 m., *Hilliard* 862, E, K, NBG, NH, NU, do., *Fisher* 869, 863, NH, NU, PRE, do., *Fisher and Schweickerdt* 101, NH, NU, PRE, do., *Codd* 9673, PRE, do., *Gerstner* 664, PRE, do., *Edwards* 1307, PRE; Madlozi Mt., *Gerstner* 4606, PRE.

Cooper's specimen is without precise locality, but it possibly came from Nelson's Kop near Van Reenen where he is known to have collected, but I could not find the species in the badly disturbed forest on this mountain, nor at Van Reenen, locality of *Wood* 5704, cited by Clarke (1904). *S. cooperi* is still growing in the neighbouring but less disturbed Colling's Pass and Cundy Cleugh areas, and therefore appears to have a limited distribution range from the Drakensberg across the Biggarsberg to Qudeni range at altitudes of between 1050 m. and 1675 m.

It is among the most handsome of the monocarpic species, with leaves attaining a metre in length, and tall peduncles bearing numbers of large, richly-coloured flowers. Its affinities lie with *S. grandis* from which it is distinguished by its much larger flowers.

3. S. saundersii Hook. in Bot. Mag. t. 5251 (1861)*; F1. Ser. 17, t. 1802 (1867–68); Regel, Gartenfl. 24, t. 826 (1875); N.E. Br. in Gard. Chron. 3:375 (1875); Nichols. Dict. Gard. 3:516 (1887); C.B. C1. in DC. Monog. Phan. 5(1):150 (1883) excl. **var. breviflos** C.B.C1. et in Dyer, F1. Cap. 4(2):443 (1904); Fritsch in Engl. and Prantl, Pflanzenfam. 4(3B):151 (1895); Tracy Hubbard in Bailey, Std. Cyclopedia Hort. 3:3274 (1937); Burtt in Kew Bull: 78 (1939) and in R.H.S. Dict. Gard. ed. 2, 4:2045 (1956); cult. spec. Herb. Hookerianum 1867, K. HOLOTYPE.

S. tubiflos C.B.C1. in Dyer, F1. Cap. 4(2):441 (1904) p.p. quoad spec. Woodianum; Burtt in Kew Bull: 79 (1939). Natal, Inanda, *Wood* 752, K, HOLOTYPE, NH, ISOTYPE.

Monocarpic. *Leaf* up to 370 × 260 mm., pilose, base deeply cordate, upper surface light green, lower sometimes deep reddish-purple, sometimes green suffused red. *Inflorescence* many flowers expanded simultaneously. *Peduncle* up to 250 mm. long, purplish-brown, pilose. *Bracts* narrowly elliptic, slightly falcate, up to 13 × 3 mm., green to brown, pilose with glandular and eglandular hairs. *Flower* 26—40 mm. long. *Pedicel* 10—17 mm. long, elongating slightly in fruit, green, pilose. *Calyx* lobes linear, 6 × 1·5 mm., green to brown, pilose. *Corolla* tube narrowly infundibuliform, slightly deflexed about the middle, whitish below and basally, medium violet or white above, scabridulous, with occasional minute glands, 13—20 mm. long, base 6 mm. diam, mouth 9 mm. diam; upper lobes divergent, ovate, 9 × 8·5 mm.; lower lip 11—22 mm. long, lobes suborbicular, 10 × 9 mm.; all lobes medium violet or white, glandular inside, paler, pubescent outside; throat, floor of tube and base of lower lip pale to medium violet longitudinally divided by a broad yellow stripe. *Stamens*: filaments inserted halfway up corolla tube, 6 mm. long, white, curved, curve dilated, yellow, sparsely glandular; anther lobes 1·5 mm. long, white, glandular;

Ovary 10 mm. long, green, appressed pubescent; style 5 mm. long, white, pubescent, minutely glandular apically. *Capsule* 44—68 (58±5) mm. long, 2·5 mm. diam.

Flowering period: December to January.

NATAL: Mapumulo dist., Jiyana river, 610 m., *Hilliard* 838, E, K, NU, PRE. Lower Tugela dist., Upper Tongaat, farm "Erradale", 430 m., *Hilliard* 839, E, NU; White Hill 700 m., *Hilliard* 837, K, E, NH, NU; Thring's Post 792 m., *Hilliard* 1007, E, NU, PRE; Ndwedwe dist., ±1 ml. E. Ndwedwe village, 530 m., *Hilliard* 854, NU. Inanda dist; Inanda, Groeneberg, in forest, *Johnson* 1312, NH; do., 428 m., *Hilliard* 831, E, K, NBG, NU, PRE; near Umhlanga, *Haygarth* s.n., K, NH.

Hooker (1861) gave no locality other than Natal for *S. saundersii*, but Clarke (1883) cited *Wood* 752 from Inanda. *S. saundersii* still grows there, and in other localities in the coastal areas north of Durban, on steep earth or rock banks in forest. There is some variation in corolla size and colour, which may vary from pure white, to white suffused palest violet, to medium violet. Only one colour form appears in any one population and the yellow streak on the floor of the tube is always distinct.

In agreement with Burtt (1939), *S. tubiflos* (type *Wood* 752, Inanda) is here reduced to synonymy. Burtt (1939) also reduced *S. breviflos* to synonmy. *S. breviflos* was founded on *Cooper* 2766, K, from the Orange Free State. Although the specimen is admittedly a poor one, the flowers are sufficiently unlike those of *S. saundersii* to arouse doubts, especially as *S. saundersii* has a limited distribution range in the Natal coastal area. *S. breviflos* should be retained as an insufficiently known species until the appropriate parts of the Orange Free State, which is very poorly explored botanically, have been searched for Cooper's plant.

S. saundersii has close affinity with *S. wendlandii* and *S. molweniensis*. All three species have scabridulous corollas and appressed pubescent ovaries, opposed to the pilose corollas and patently hairy ovaries of *S. grandis* and *S. cooperi*. The short and relatively broad corolla tube of *S. saundersii* is easily distinguished from the narrowly subcylindric corolla tubes of *S. wendlandii* and *S. molweniensis*.

The existence of anomalous populations having close affinity with one species yet displaying characteristics of another has already been discussed and attention drawn to one such population (putative *S. polyanthus* ssp. *verecundus* x *S. prolixus*) in a rock cleft at Kingscliffe in the Great Noodbserg (Hilliard, 1966). A second anomalous population (*Hilliard* 832, NU) grows in the same cleft but is confined to its mouth where environmental conditions differ from those obtaining further back in the hillside.

The plants grow on a steep earth bank sheltered by overhanging trees and do not encroach upon the sheer rock faces favoured by the other putative hybrid population. The second population is very small, probably not more than fifty plants during any one season. The road up the face of the Kingscliffe escarpment cuts across the mouth of the cleft and it is possible that the area of suitable habitat has been much reduced in size.

Second anomalous population at Kingscliffe

Monocarpic, all parts pilose, eglandular. *Leaf* c. 160 × 140 mm., green above, reddish-purple below. *Inflorescence* several flowers expanded simultaneously. *Peduncle* up to 180 mm. long. *Flower* 22—27 mm. long. *Calyx* lobes linear, c. 3 × 1 mm. *Corolla* tube narrowly infundibuliform, slightly deflexed about the middle, white, c. 18 mm. long, base 3 mm. diam., throat c. 6 mm. diam.; upper lobes divergent, elliptic, c. 4 × 3 mm.; lower lip c. 7 mm. long, lobes broadly elliptic, c. 5 × 4 mm.; all lobes white, no markings on lower lip or floor of tube. *Stamens:* filaments inserted about halfway up corolla tube. *Ovary* c. 8 mm. long, appressed pubescent; style c. 7 mm. long, appressed pubescent. *Capsule*, immature, up to 45 mm. long.

The affinities of this population obviously lie with *S. saundersii*. The plants, which are phenotypically uniform, have red leaf undersurfaces and the same type of corolla and ovary indumentum as that species, but the corolla tube is longer and narrower than in typical *saundersii*, being similar in form to that of *S. grandis*. The corolla is white, but lacks the yellow stripe on the floor of the corolla tube, always present in *saundersii*. Herbarium material of this plant is easily mistaken for *S. grandis*. The type of indumentum on the corolla tube and ovary, however, suggests *S. saundersii*.

Fig. 1 shows the known distribution range of *S. grandis* and *S. saundersii*. The Great Noodsberg lies between the areas occupied by *S. grandis* (inland towards Pietermaritzburg and Sevenoaks) and *S. saundersii* (coastwards towards Ndwedwe and Upper Tongaat). It appears that the second Kingscliffe population is of possible hybrid origin and, like the first, has become established as a homogeneous entity in an area intermediate between the distributional ranges of the putative parents.

4. S. molweniensis Hilliard sp. nov. propinquus *S. wendlandii* Sprenger sed floribus minus numerosis paucis simul expansis, corollae tubo et capsula longioribus.

Herba acaulis, monocarpica aut terrestris aut rupicola. *Folium* 1, usque 350 × 300 mm., pilosum, ima parte cordata, apice usta, margine crenata, supra rugulosa, virens, venis impressis, infra pallidior, venis prominentibus. *Inflorescentiae* cymosae, ex ordine ab superficie adaxiali prope partem imam costae mediae orientes; flores plurimi, pauci eodem tempore expansi. *Pedunculus* ad 450 mm. longus, fusco-viridis, pilosus. *Bracteae* lanceolatae, ad 8×1·5 mm., virides, pilosae. *Flos* 30—40 mm. longus. *Pedicellus* 10 mm. longus, sub fructu elongatus, viridis, pilosus. *Calyx* quinque partitus; lobi lineares, 4×1 mm., virides, pilosi. *Corolla* bilabiata; tubus anguste subcylindricus, circa medium abrupte deflexus, albus adapicem pallide ianthino-suffusus, scabridulus, 18—24 mm. longus, in fauce 7 mm. latus; limbus obliquus; lobi superiores divergentes, suborbiculares, 5—7×5—6 mm.; labrum inferius 9—14 mm. longum, lobis suborbicularibus, 5—9×5—8 mm.; lobi omnes albidi, extra parce pilosi, mediocriter ianthini, intus dense glandulosi, fauce soloque tubae intense ianthino, linea lata alba paullum in labrum inferius extendente bisecto. *Stamina* fertilia 2; filamenta duabus partibus supra basin corollae tubae orientia, 5 mm. longa, curvata, medio paullum dilatata, alba, glabra; antherarum lobi confluentes, 1·5 mm. longi, albi, glandulosi; staminodia 3, minima. *Ovarium* 11 mm. longum, viride, pubescens; stylus 6 mm. longus; stigma stomatomorphum, papillosum. *Capsula* torta, bivalva, 69—119 (92 ± 12) mm. longa, 1·5 mm. lata.

NATAL: Pinetown dist., Everton, Eskotene, Molweni river kloof, c. 600 m., *Hilliard* 1137, NU, HOLOTYPE, E, K, NH, PRE, ISOTYPES. Camperdown dist., on road to Shongweni, McIntosh Falls on upper Unhlatuzana River, 563 m., *Hilliard* 841, E, K, NH, NU. Pinetown dist., Everton, Eskotene, spring falling into main Molweni kloof, 600 m., *Hilliard* 849, E, K, NH, NU, PRE; Kloof, small kloof off Buckingham road, c. 550 m., *Hilliard* 1164, NU. Durban dist., Coedmore, Stainbank Nature Reserve, *Campbell* 253, NU.

Monocarpic. *Leaf* 1, up to 350×300 mm., pilose, base cordate, upper surface medium green, lower paler. *Inflorescence* flowers numerous, few expanded simultaneously. *Peduncle* up to 450 mm. long, greenish-brown, pilose. *Bracts* lanceolate, up to 8×1·5 mm., green, pilose. *Flower* 30—40 mm. long. *Pedicel* 10 mm. long, elongating in fruit, green, pilose. *Calyx* lobes linear 4×1 mm., green, pilose. *Corolla* tube narrowly subcylindric, abruptly deflexed about the middle, white suffused palest violet apically, scabridulous, 18—24 mm. long, base 4 mm. diam., throat 7 mm. diam.; upper lobes divergent, suborbicular 5—7×5—6 mm.; lower lip 9—14 mm. long, lobes suborbicular, 5—9×5—8 mm., all lobes whitish, sparsely pilose outside, medium violet, densely glandular inside, throat and floor of tube deep violet bisected by a broad white stripe extending briefly onto lower lip, where it is flanked by white wedges at base of lateral lobes. *Stamens:* filaments inserted two-thirds up corolla tube, 5 mm. long, curved, curve slightly dilated, white, glabrous; anther lobes 1·5 mm. long, white, glandular; staminodes minute. *Ovary:* 11 mm. long, green, appressed pubescent; style 6 mm. long, white, pubescent. *Capsule* 69—119 (92 ± 12) mm.

long, 1·5 mm. in diam.

Flowering period: December to February.

S. molweniensis grows on steep earth or rock banks in stream-bank forest, and appears to be confined to wooded kloofs within twenty miles of Durban. Except for differences in colour tone and intensity, it shows no significant variation.

Its closest ally is probably *S. wendlandii* from which it is distinguished by its less robust habit, leaves green rather than red below, less floriferous inflorescence, longer corolla tube and shorter lower lip. It also has affinity with *S. saundersii*, but the short, relatively broad corolla tube of that species is distinctive. Both *S. wendlandii* and *S. saundersii* have capsules considerably shorter than those of *S. molweniensis*.

5. S. wendlandii Sprenger in Damman Cat: 80 (1890); W. Wats. in Gard Chron. 15:590 (1894); Hook. f. in Bot. Mag. t. 7447 (1895)*; Journ. Hort. ser.3, 28:223 fig. 37; C.B.Cl. in Dyer, Fl. Cap. 4(2):44 (1904); Tracy Hubbard in Bailey, Std. Cyclopedia Hort. 3:3274 (1937)*; Burtt in R.H.S. Dict. Gard. ed. 2, 4:2045 (1956).

NATAL: Zululand, *Medley Wood* 3944, K, NH, proposed NEOTYPE. Hort. Bot. Reg. Kew 1895 is the type of Bot. Mag. t. 7447 (2 sheets).

"*S. saundersii*" (illustration only) non Hook. sec. Marloth in Fl. S. Afr. 3(2):161 t. 42 (1932)*.

Monocarpic. *Leaf* up to 450×350 mm., pilose, base cordate, upper surface medium green, lower dark reddish-purple, hypocotyl conspicuous, up to 100 mm. long, 10 mm. diam. *Inflorescence* many flowers expanded simultaneously. *Peduncle* up to 550 mm. long, reddish-brown to green, pilose. *Bracts* linear, up to 15×4 mm., reddish-brown to green, pilose. *Flower* 35—50 mm. long. *Pedicel* 14 mm. long, elongating slightly in fruit, green, pilose. *Calyx* lobes linear, 6×1·5 mm., green to reddish-brown, pilose. *Corolla* tube narrowly subcylindric, deflexed about the middle, medium violet adaxially, whitish abaxially, scabridulous, c. 18 mm. long, base 4·5 mm. diam.; upper lobes divergent, suborbicular, 8—11×8—12 mm.; lower lip 15—24 mm. long, lobes broadly elliptic, 10—14×7—12 mm.; all lobes medium violet, glandular inside, whitish, pilose outside; throat deep violet, bisected by a white streak extending onto lower lip where it is flanked by white wedges. *Stamens:* filaments inserted two-thirds up corolla tube, 4 mm. long, curved, curve slightly dilated, white sometimes suffused violet, sparsely glandular; *Ovary* 10 mm. long, greenish-yellow, appressed pubescent; style 4 mm. long, white, pubescent. *Capsule* 47—87 (64 ± 8) mm. long, 2·5 mm. diam.

Flowering period: December to March.

NATAL: Mtunzini dist., Ngoye forest, *Wood* 10865, NH, do., *Wood* 5719, K, do., 275 m., *Hilliard* 834, NU, do., legit P. Ellis, *Hilliard* 2609, NU, 2707, E, NU, do., *Huntley* 288, PRE; do., *Wood* 10, 346, PRE.

This species was originally described in a seed catalogue, the seed having been sent to Messrs. Damman by Medley Wood in 1887, as a letter attached to *Wood* 3944, K, indicates. The existence of a type specimen is doubtful. *Wood* 3944, K, NH, is therefore proposed as NEOTYPE, this being Wood's first gathering of the species.

Medley Wood collected seed and seedlings of a *Streptocarpus* in Zululand in 1887. The seed was sent to Damman of Naples, resulting in the description of *S. wendlandii*. Wood grew the seedlings at the Botanical Gardens in Durban, and in 1888 selected some for herbarium sheets (*Wood* 3944). Although Wood gave no precise locality in Zululand for these gatherings, it can be deduced that they came from Ngoye, because all specimens of *S. wendlandii* from Ngoye have a very distinctive short corolla tube and the corolla tube in *Wood* 3944 is short.

S. wendlandii was subsequently poorly described (and poorly illustrated) by Hooker (1895) and by Clarke (1904). Hooker's description was of a living plant of unstated origin, and he confused the issue still further by mistakenly calling *S. wendlandii* a native of the Transvaal. Clarke (1904) based his description on cultivated specimens and *Wood* 3944, and erroneously described the inflorescence as 6—8 inches long. Clarke (1904) also commented on *Wood* 5719 from Ngoye, the small calyx and corolla of which he considered brought it close to *S. tubiflos*. *Wood* 5719 is undoubtedly *S. wendlandii*. The range of variation in corolla size within any one population of *S. wendlandii* embraces the small flower size of this specimen.

S. wendlandii is a distinctive plant. Although the red undersurface of the leaf is not always a reliable character within *Streptocarpus*, in *S. wendlandii* it is strongly marked and appears to be constant. All the early descriptions draw attention to the beautiful colour of the leaf undersurface, and every specimen so far examined was red below. Again, in many species of *Streptocarpus*, the hypocotyl may or may not be conspicuous. In *S. wendlandii* it is always well developed so that the leaf is partly raised off the ground.

The species is, apparently, endemic to Ngoye forest where it favours steep earth banks, rock faces, or even grows epiphytically, always within the forest itself. *S. polyanthus* ssp. *verecundus* grows in crevices of the huge granite domes on the outskirts of the forest, sheltered by aspect or by the marginal fringe of vegetation where bare rock gives way to forest. Plants intermediate between this species and *S. wendlandii* are occasionally found in the intermediate zone of forest margin vegetation.

S. wendlandii is a most handsome plant, with its large leaf and tall inflorescences massed with pale violet flowers. In size and floriferousness, it is reminiscent of *S. cooperi* but is distinguished from that species by its narrower and differently shaped corolla tube, scabridulous rather than pilose; the appressed pubescent ovary and shorter capsule. The leaf of *S. cooperi* is always green below and the hypocotyl seldom conspicuous. The closest allies of *S. wendlandii* are *S. molweniensis* and *S. saundersii*, with which it shares the same type of corolla and ovary indumentum. *S. wendlandii* and *S. saundersii* both have red leaf undersurfaces (which, however, are not strongly marked in the white and pale colour forms of the latter species) and relatively short capsules, but the corolla tube of *S. saundersii* is narrowly infundibuliform rather than subcylindric and proportionately broader in relation to its length. *S. molweniensis* and *S. wendlandii* have been compared and contrasted under the description of the former species.

Anomalous populations at Eshowe

Wood collected specimens (*Wood* 11101, NH) from "Eshowe Bush" which he determined as *S. wendlandii*. These plants differ from Ngoye *wendlandii* mainly in the length of the corolla tube and of the lower lip, but there are also subtle differences, difficult to express, in the shapes of both these organs. The two are undoubtedly closely related, but there is sufficient difference to arouse doubts about their conspecificity. These doubts are heightened by the very close resemblance between the flowers of the Eshowe plant and those of *S. molweniensis*. They differ mainly in size. The most striking differences between the three taxa are tabulated below.

S. wendlandii, Ngoye	Eshowe plants	*S. molweniensis*
Leaf rich beetroot red below.	Leaf, sometimes rich red below, sometimes suffused red.	Leaf usually green below, occasionally suffused red.
Hypocotyl always conspicuous.	Hypototyl usually conspicuous.	Hypocotyl only occasionally conspicuous.
Inflorescence tall, stout, many flowers open simultaneously.	Inflorescence less robust, few flowers open simultaneously.	Inflorescence still less robust, only one or two flowers open simultaneously.
Corolla tube 18 mm. long.	Corolla tube 26 mm. long.	Corolla tube 21 mm. long.
Lower lip 15—24 (22) mm. long.	Lower lip 18 mm. long.	Lower lip 9—14 (12) mm. long.
Capsule 64 ± 8 mm. long.	Capsule 65 ± 5 mm. long.	Capsule 92 ± 12 mm. long.

Fl. Pl. S. Afr. t. 803, purporting to illustrate and describe *S. grandis*, is another facet of the problem. The plate was drawn from specimens sent by Fr. Gerstner from Eshowe. His herbarium specimen (*Gerstner* 3152, PRE), which accompanied the living material, matches *Wood* 11101: they have the same indumentum, red leaf undersurface, and prominent hypocotyl. The plant illustrated, grown from a seedling, and preserved under the same collector's number, 3152, has a broader corolla tube and a shorter lower lip than the wild plant, but the same type of indumentum. Neither specimen is *S. grandis*. One is identical with, the other very close to, *Wood* 11101, and *Hilliard* 2135, NU, from the Mpusheni Falls, Eshowe. *Gerstner* 3197, PRE, from the gorge east of the Mpusheni Falls matches *Hilliard* 2135, while *Gerstner*, sn, PRE 22608 from "Eshowe Bush" has a corolla tube widening slightly upwards but is otherwise very similar to the other three specimens.

Gerstner reported, in 1939, that the plants were very plentiful around the springs in the Hlinza and Mpusheni forests at Eshowe (see Fl. Pl. S. Afr. t. 803). The town of Eshowe partly encroaches upon the two forests, which are now a nature reserve much visited by the general public. In 1963 I could find no trace of these interesting plants except for one small population below the Mpusheni Falls, and neither the Ranger nor local residents interested in wild plants had even seen them. It has therefore proved impossible to assess either the past or present extent of the populations or their degree of variation. The Eshowe plants, like those at Kingscliffe (Page 162) are anomalous, and appear to be intermediate between *S. wendlandii* and *S. molweniensis*.

Ngoye forest, the only known locality for *S. wendlandii*, lies about ten miles east of Eshowe. *S. molweniensis* is apparently confined to coast forest near Durban. Coast forest once stretched almost uninterruptedly from Zululand to the Transkei (see Fourcade, 1889) and most of the clearing has taken place within the last eighty years. Species that once grew near the coast have disappeared and are now found only further inland. For example, Wood recorded *S. gardenii* from Umhloti and Haygarth collected *S. saundersii* near Umhlanga, but they have not been found again, despite careful searching in surviving forest patches between Durban and the Umvoti river mouth.

It is feasible that *S. molweniensis* and *S. wendlandii* were once in much closer contact than they are at present and that the Eshowe plants are the result of natural interspecific hybridisation followed by isolation in relics of formerly extensive forest. The view that these anomalous populations and others already described both in this paper and elsewhere (Hilliard, 1966) are relict hybrids can be proved correct only by genetical studies and by reconstituting the hybrids experimentally.

6. S. porphyrostachys Hilliard sp. nov. nulli arcte similis, sed affinitatem *S. grandi* N.E. Br. et *S. saundersii* Hook. habens; ab eis et forma et magnitudine et colore folii corollaeque distincta.

Herba rhizomatosa, terrestris vel rupicola. *Folium* unicum ad 250 × 120 mm., aliis 1—2 parvis ex rhizomate minimo orientibus adjacentibus, pilosum, ima parte terete, apice usta, margine crenato, supra rugulosa, pullo-viridissima, venis impressis; infra clare purpurea, venis eminentibus. *Inflorescentiae* cymosae, 3 aut 4 exordine ab superficie abaxiali prope basin costae mediae; flores pauci (c. 24), complures simul aperti. *Pedunculus* ad 260 mm. longus, gracilis, rubro-fuscus, parce pilosus. *Bracteae* lineares, ad 5 mm. longae, parce pilosae. *Flos* 30—43 mm. longus. *Pedicellus* 12—30 mm. longus, rubro-fuscus ad viridem, paene glaber. *Calyx* quinquepartitus; lobi lineares, 3 × 1 mm., fusco-virides, parce pilosi. *Corolla* bilabiata; tubus 16—26 mm. longus, anguste cylindricus infra ad orem versus ventricosus, flectus praecipue circum partem mediam flexus, parce pilosus, ianthinus, infra ad orem albus; limbus obliquus; lobi superiores suborbiculares, 5—8 × 5—7 mm.; labrum inferius 13—17 mm. longum, lobis oblongis, 8—10 × 6—7 mm.; lobi omnes ianthini, extra paene glabri, intus subtiliter glandulosi, tubae solo et ima parte labri inferioris cuneis sex albis notis purpureis claris divisis notato. *Stamina* fertilia 2; filamenta c. 5 mm. longa, curvata, in media parte dilatata, pallide ianthina, glandulosa, duabus partibus corollae tubi orientia; antherarum lobi confluentes, 1·5 mm. longi, pallide ianthini; staminodia 3, posterius minimum, lateralia 2 mm. longa, pallide ianthina. *Ovarium* c. 12 mm. longum, fuscum, subtiliter pubescens; stylus 8—12 mm. longus, pallide ianthinus, parce pubescens; stigma stomatomorphum, papillosum. *Capsule* bivalva, torta, 40—66 (48 ± 7) mm. longa.

NATAL: Port Shepstone dist., small kloof dropping into Umtamvuna river, c. 3·5 mls. Port Edward on Izingolweni road, c. 300 m., *Hilliard* 3052, NU, HOLOTYPE, E, K, NH, ISOTYPES.

NATAL: Port Shepstone dist., c. 4 mls. Port Edward on Izingolweni road, *Hilliard* 3051, K, NU, PRE; c. 3 mls. Port Edward on Izingolweni road, *Hilliard* 3050, E, K, NU.

Rhizomatous, terrestrial or lithophytic, perennial herb. *Leaf* 1, with one or two smaller ones developing from the very small rhizome and lying in the same plane as the flowering leaf, up to 250 × 120 mm., pilose with glandular and eglandular hairs, base rounded to cuneate, apex withered, margin crenate, upper surface rugulose, dark green, veins impressed, lower rich purple, veins prominent. *Inflorescences* several in acropetal succession from base of midrib and apex of rhizome, flowers few (c. 24), several open simultaneously. *Peduncle* up to 260 mm. long, slender, reddish-brown, sparsely pilose. *Bracts* linear, up to 5 mm. long, sparsely pilose to almost glabrous. *Flower*

30—43 mm. long. *Pedicel* 12—30 mm. long, reddish-brown to green, almost glabrous. *Calyx* 5-partite, lobes linear, 3 × 1 mm., brownish-green, sparsely pilose. *Corolla* bilabiate, tube 16—26 mm. long, base c. 4 mm. in diam., mouth c. 8 mm., narrowly cylindric below, widening abruptly about the middle, ventricose, slightly declinate, sparsely pilose, violet, white below near mouth; limb oblique, upper lobes suborbicular, 5—8 × 5—7 mm.; lower lip 13—17 mm. long, lobes oblong-elliptic, 8—10 × 6—7 mm.; all lobes violet, almost glabrous outside, minutely glandular inside particularly on two upper lobes in mouth of tube, floor of tube and base of lower lip marked with white wedges separated by deep violet streaks. *Stamens*: filaments inserted two-thirds up corolla tube, c. 5 mm. long, curved, dilated, violet, glandular; anther lobes 1·5 mm. long, pale violet; posterior staminode minute, laterals 2 mm. long, pale violet. *Ovary* c. 12 mm. long, brown, minutely pubescent with acute antrorse hairs and short-stalked, patent glands; style 8—12 mm. long, pale violet, sparsely pubescent; stigma pale violet. *Capsule* 40—66 (48 ± 7) mm. long

Flowering period: November to January.

S. porphyrostachys is known only from the gorges of the Umtamvuna and its tributaries, but probably occurs in the botanically unexplored area lying southward in the Transkei. The rich dark colouring of flowers and foliage is most distinctive and the relatively small, very dark green leaf, with its purple-red undersurface, makes recognition of even non-flowering specimens simple. It grows on rock faces or steep earth banks, either in forest or under rock overhangs along the lips of the gorges, wherever seepage or streamlets provide suitably damp situations. The plants appear solitary-leaved, but at the base of the leaf is a very small rhizome, which produces one or two new leaves lying in the same plane as the flowering leaf. Old, dry peduncles can sometimes be seen at the base of a flowering leaf, indicating perennation.

S. porphyrostachys appears to hybridise naturally with an undescribed rosulate plant allied to *S. primulifolius* Gandoger, which is widespread in the Umtamvuna gorges but which favours a rather drier habitat than does *S. porphyrostachys*. One plant intermediate between the two taxa was seen.

In its indumentum and short capsule *S. porphyrostachys* resembles *S. saundersii* from which, however, it differs markedly in the shape and colouring of the corolla tube and limb. Its flowers resemble in colour and markings *S. cooperi* and the Nkandla form of *S. grandis*, but the sparsely pilose corolla tube, narrowly cylindric below, almost saccate above, is quite different from the narrowly infundibuliform, pilose and glandular corolla tubes of those two species.

References

Brown, N. E., 1905. *S. grandis* in Bot. Mag. t. 8042.

Burtt, B. L., 1939. Notes on *Streptocarpus* in Kew Bull.: 68—84.

Burtt, B. L., 1958. Studies in the Gesneriaceae of the Old World. XVI. Some Tropical African *Streptocarpus* in Notes Roy. Bot. Gdns. Edinb. **22:** 569—579.

Burtt, B. L. and Sealy, J. R., 1946. *S. polackii* in Bot. Mag. t. 9668.

Clarke, C. B., 1904. Gesneriaceae in Dyer, Fl. Cap. **4(2):** 438—447.

Fourcade, H. G., 1889. Report on the Natal Forests. 197 pages.

Hilliard, O. M., Studies in *Streptocarpus*, 1966. The *S. polyanthus* alliance in Jnl. S. Afr. Bot. **32**(1): 87—123.

Lawrence, W. J. C., 1957. Studies in *Streptocarpus*. IV. Genetics of flower colour patterns in Heredity 11: 336—357.

Index to main reference to species, and to natural interspecific hybrids and anomalous populations

S. breviflos p. 162
S. cooperi p. 160
S. grandis p. 155
S. grandis x S. gardenii p. 160
S. grandis x S. haygarthii p. 160
S. grandis x S. confusus p. 160
S. molweniensis p. 163
S. porphyrostachys p. 169
S. porphyrostachys x undescribed rosulate p. 170
S. saundersii p. 161
S. tubiflos p. 161
S. wendlandii p. 165
S. wendlandii x S. polyanthus ssp. verecundus p. 166
Anomalous Eshowe populations p. 167
Anomalous Kingscliffe populations p. 162

EUPHORBIA SPECIES FROM THE FLORA ZAMBESIACA AREA: V

L. C. Leach

Euphorbia confinalis R. A. Dyer in Bothalia **6,** 1: 222 (1951).—Codd, Trees & Shrubs, Kruger Nat. Park: 98 (1951).—Jacobsen, Handb. Succ. Pl. 1: 421 (1960).—Boughey, Check List Trees S. Rhodesia, in Journ. S. Afr. Bot. **30:** 162 (1964). Type: Transvaal, Pilgrims Rest Distr., *Codd & De Winter* 5580 (PRE).

Euphorbia cooperi sensu Hutchinson, Bot. S. Afr.: quoad fig. opp. 321 (1949).

The distribution of this species is much wider than was apparently at first thought and two subspecies may be recognised.

Subsp. **confinalis.**

Trunk initially 3—5 angled (most commonly 4), usually simple or occasionally with 1—2 trunk-like branches (seldom more than 2); ultimate branches 3—4 or rarely 5 angled; involucral bracts wider than long, shorter than the involucre.

Transvaal.—Zoutpansberg Distr., ±7 miles SW of Punda Maria, 6. ix.. 1947, *Codd* 3026 (PRE); 6·5 m. NW of Punda Maria, st. 25. vii. 1951, *Rowland-Jones* 53 (PRE); cult. Pafuri, fl. & fr. Aug.–Sept. 1964, *Mockford* in *Leach* 12529 (PRE; SRGH). Pilgrim's Rest Distr., 2 m. E of Gorge Camp, Kruger Nat. Park, fl. 20. v. 1949, *Codd & De Winter* 5580 (PRE); Satara Camp, Kruger Nat. Park, fr. 6. viii. 1950, *Swartz* comm. *Codd* s.n. (PRE; SRGH); Nwanetsi, Kruger Nat. Park, fl. 17. vi. 1952, *Van der Schijff* 510 (PRE). Letaba Distr., Letaba, Kruger Nat. Park, fl. 7. vi. 1954, *Van der Schijff* 3860 (PRE). Barberton Distr., ±25 m. SE of Hectorspruit, 21. iv. 1953, photo. *Codd* s.n. (PRE).

Moçambique.—Lourenço Marques Distr., Ressano Garcia, fl. 1936, *Van der Merwe* E17 (PRE), fl. July 1938, *Van der Merwe* 1698 (PRE); ± 6 m. W of Moamba, fl. 4. vi. 1947, *R. A. Dyer* 4799 (PRE; SRGH); ± 20 m. S of Ressano Garcia, fr. 29. vii. 1961, *Leach* 11211 (PRE; SRGH); ± 10 m. S of Boane, st. 14. x. 1963, *Leach & Bayliss* 11932 (G; K; LISC; PRE; SRGH); ± 10 m. N of Moamba, fl. 28. vi. 1964, *Leach* 12263 (COI; G; K; LISC; PRE; SRGH). Manica e Sofala Distr., Buzi Riv., near Gogoi, st. 23. xi. 1960, *Leach & Chase* 10532 (PRE; SRGH).

S. Rhodesia.—Chipinga Distr., Chibunje, fl. ♂ July 1964, *D. C. Plowes* 2442 (SRGH).

The distribution of the typical subspecies extends generally along the Lebombo range and its foothills, in both S. Africa and Moçambique (being particularly plentiful in the vicinity of Komatipoort and Ressano Garcia) but is, however, by no means confined to the rocky hills and ridges of this range; it occurs frequently also on the deep soils of the low altitude coastal plain of Moçambique. Numerous communities are to be found in the thick bush country to the south of Boane and there is a magnificent "stand", several acres in extent, near the Inkomati Riv., about 10 miles north of Moamba. Somewhat disjunct communities also occur at Chibunje, on deep alluvium, near the Sabi Riv. in the Chipinga Distr. of S. Rhodesia and along the Buzi Riv. not far from its source, near Espungabera in the Manica e Sofala Distr. of Moçambique; at this latter locality the trunks are fairly consistently initially 3-angled as also are the majority of the branches.

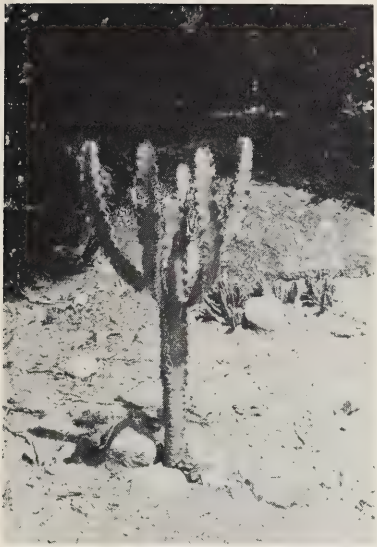
Subsp. **rhodesiaca** Leach, subsp. nov.

A subspecie typica trunco initio 5—6 angulato plerumque ramis trunciformibus paucis instructo, ramis ultimis spinosis 4—5 angulatis validius armatis, involucri bracteis saepe longioribus quam latioribus, plerumque quam involucrum paulo longioribus differt.

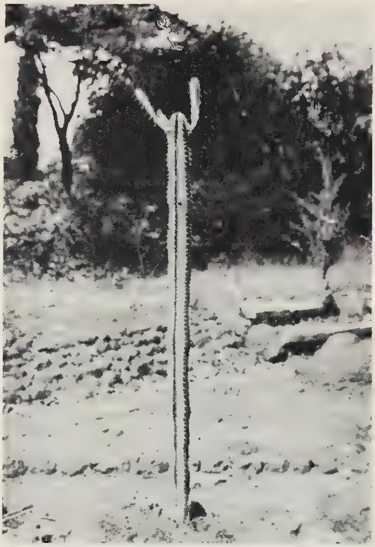
Type: S. Rhodesia, Chibi Distr., *Leach* 9346 (PRE holotype; SRGH).

S. Rhodesia.—Chibi Distr., ± 1 mile S of Chibi, fl. & fr. 26. viii. 1959, *Leach* 9346 (PRE; SRGH); photo. *Leach* 5041 (PRE). Bikita Distr., Moodies Pass, cult "Ewanrigg" st. Aug. 1942, *Vereker* in *Christian* 1125 (PRE); on granite slopes, fl. 27. viii. 1959, *Leach* 9324 (PRE; SRGH).

Plants of this subspecies have a rather stouter facies and differ from the typical in having an initially 5/6-angled trunk which usually has one or several trunk-like branches each with a crown of 4/5-angled branches which are generally more strongly armed than those of the typical subspecies; the spine shields are also usually hornier, wider and more distinct (degeneration of both spines and shields does occur, but not nearly as frequently as in the subsp. *confinalis*), while the larger involucral bracts are often longer than wide, usually partially exceeding the involucre. It is, however in the juveniles that the differences are most evident; those of the subsp. *confinalis* are relatively stout, 3—4 or rarely 5-angled with the sides only slightly, if at all, concave, pale or dull green in colour and almost or entirely without markings, branching usually commencing while the plants are no more than 30 cm. high. These characters contrast sharply with those of young plants of the subsp. *rhodesiaca* which are relatively slender, 5/6-angled with the sides usually deeply sulcate and conspicuously marbled or feather marked with dark green; branching seldom occurs until plants are 1 m. or more in height and even then only relatively sparingly and vestigially.



Juvenile typical of the subsp. *confinalis*. Ht. c. 30 cm.



Juvenile typical of the subsp. *rhodesiaca*. Ht. c. 1 m.

The Chibunje population is, to a slight extent, intermediate, the juveniles exhibiting compressed angles and dark green marbling in their coloration; however in all other respects, e.g. habit, count of angles and spinescence, these plants fall within the circumscription of the subsp. *confinalis*.

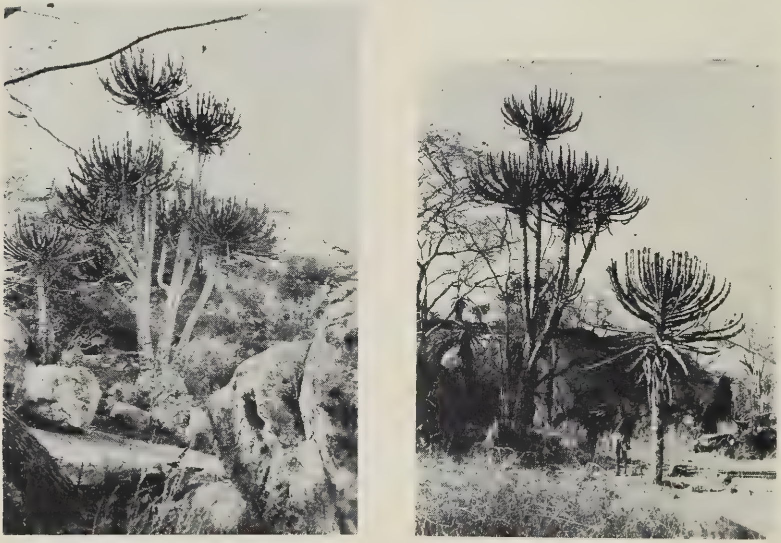
It is interesting to note that this taxon is recognised by the natives as being distinct from the other tree species present in the area; its name in the Chikaranga dialect (S. Rhodesia) being *urudu* whilst those of *E. ingens* Meyer and *E. cooperi* N. E. Br. are *ngonde* and *chikondekonde* respectively.

It is probable that *E. confinalis* is included in Sim's concept of *E. grandidens* in For. Fl. & For. Res. P.E.A.: 1105 (1909), which appears (as suggested by Sim) to include several taxa. The plants discussed by White, Dyer & Sloane under *E. triangularis* Desf. in The Succ. Euphorb., 2: 895 & fig. 1023 (1941) also belong here.

Throughout its distribution range the species is very variable in some of its floral characters and wide variations may be observed in the shape and size of the bracts, gland shape, degree of development of the perianth and even in the pattern of the hood above the ovule; it is, however, only in the involucral bracts that there appears to be any correlation with the subspecies, those of the subsp. *rhodesiaca* being the longer (usually slightly exceeding the glands).

The latex, whilst not having any acrid odour, is apparently extremely virulent; an African assistant once had to be taken back to Salisbury with a badly swollen face, due apparently to his having rubbed it with his hands after handling specimens. This is the most violent reaction observed by the author, bearing in mind the secondhand nature of the contact.

E. confinalis is a slow growing species; plants in cultivation at Greendale, S. Rhodesia, have gained only about 50—70 cm. in height in more than 10 years. The smallest plant yet seen to have reached the flowering stage was about 3·5 m. high and must therefore already have been quite an age.



Adult plants typical of the subsp. *rhodesiaca*. Near Chibi, S. Rhodesia.

Euphorbia ramulosa Leach, sp. nov.

E. schinzii Pax affinis sed ramis ramulosis rigidis, marginibus corneis continuis, cymis pedunculatis, ramis cymarum longioribus, floribus masculis numerosioribus, stylis brevioribus differt.

Frutex succulentus spinosus pulvinatus pumilus perrariter quam 15 cm. altior, ramosissimus, ramulis confertis rigidis. *Rami* et *ramuli* quadrangulares

tuberculato-dentati, in segmenta non constricti, rigidi erecti, versus apicem truncatum c. 1 cm. crassi; rami primi usque ad 17 cm. longi, versus basem subteretes ad 2 cm. crassi; tuberculorum dentes plus minusve deltati truncati vel subtruncati, usque ad 2·5 mm. alti, 8—12 mm. distantes. *Podaria* plus minusve lineari-obtriangularia confluentia cornea albo-grisea. *Spinae* binae divergentes apice tuberculi dispositae suberectae vel patulae, plerumque c. 5 mm. longae (ad 8 mm.). *Folia* minuta mox decidua; foliorum cicatrices inconspicuae spinulis binis minutis praeditae. *Inflorescentia* cymosa breviter pedunculata, ex axillis tuberculorum producta, cyathiis 3 horizontaliter dispositis; pedunculus bibracteatus, 1—3 mm. longus; bracteae late ovatae denticulatae c. 1 mm. longae; cyathium medium masculinum deciduum; cyathia lateralia bisexualia, ramis cymarum bibracteatis; bracteae plus minusve ovatae emarginatae irregulariter denticulatae c. 1·5 mm. longae. *Involucrum* glabrum latissime infundibuliforme 3·5—5·25 mm. diam., 1·75—2·75 mm. longum, lobis 5 transverse late ellipticis irregulariter breviter fimbriatis c. 1·5 mm. longis; glandulae 5 planae vel leviter concavae minute foveolatae, transverse anguste oblongae contiguae patulae 1·5—2·75 mm. latae. *Flores masculini* 25, 5-fasciculati, bracteolis fimbriis filiformibus c. 2·5 mm. longis; bracteae fasciculares late flabellatae breviter fimbriatae laciniatae; pedicelli c. 2·5 mm. longi. *Ovarium* in cyathio ab initio inclusum mox partim exsertum. *Styli* 1—1·2 mm. longi, libri fere ad basem, patuli reflexique, apicibus capitatis integris vel emarginatis rugulosis pellucidis. *Capsula* obtuse trilobata c. 3 mm. diam., 3·25 mm. longa, ex involucro partim exserta pedicello leviter sulcato c. 1·5 mm. longo. Semen ellipsoideum c. 1·75 mm. longum, 1·2 mm. diam. verrucosum griseo-brunneum, verruculis pallidis.

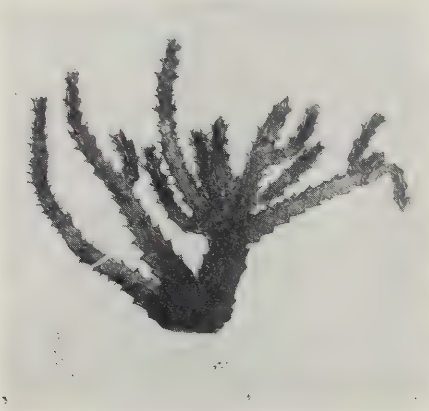
Type: *Leach & Schelpe* 11440 (K; LISC; PRE; SRGH, holotype).

Moçambique. Moçambique Distr.: ± 60 km. W of Nampula, approx. 15° 1′ S, 38° 50′ E, in crevices on steep granite slope, alt. c. 800 m., st. 23. v. 1961, *Leach & Rutherford-Smith* 10975 photo. (K; LISC; PRE; SRGH), cult. Greendale, S. Rhodesia, fl. & fr. 1963 *Leach & Schelpe* 11440 (K; LISC; PRE; SRGH).

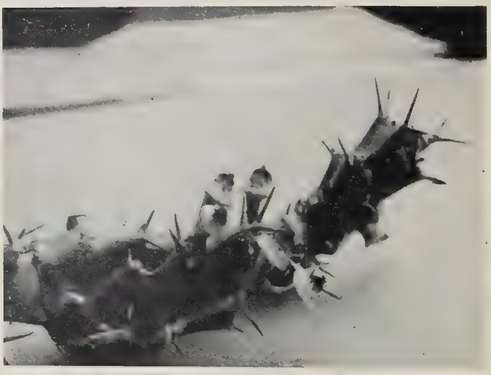
Euphorbia ramulosa is a member of the large group of shrubs and undershrubs characterised by 4-angled branches, sessile or subsessile capsules and verrucose seeds; its closest relationship seems to be with the widespread and extremely variable *E. schinzii* although there are also close ties with *E. tetracanthoides* Pax and it is thought that *E. ramulosa* may eventually prove to be more closely related to this latter species which is, unfortunately, not very well known.

The new species differs from *E. schinzii* in its continuous horny margins,

pedunculate cymes and long cyme branches, more numerous male flowers, and shorter styles, while the more ramulose branches are much more rigid than those of its relatives.



Portion of plant with branchlets.

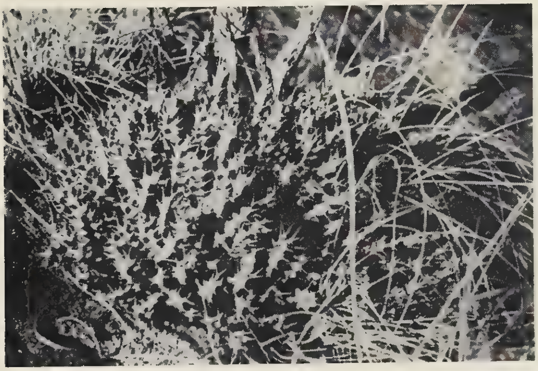


Flowering branchlet.

Fruiting branchlet.

The distribution of *E. ramulosa*, as presently known, is confined to one large, isolated, granite hill where plants are found growing wedged in crevices on the steep slopes, in association with another *Euphorbia* sp. aff. *E. graniticola* Leach, *Aloe mawii* Christian, *Selaginella njamnjamensis* Hieron, *Vellozia* spp. etc.

Typical habitat.

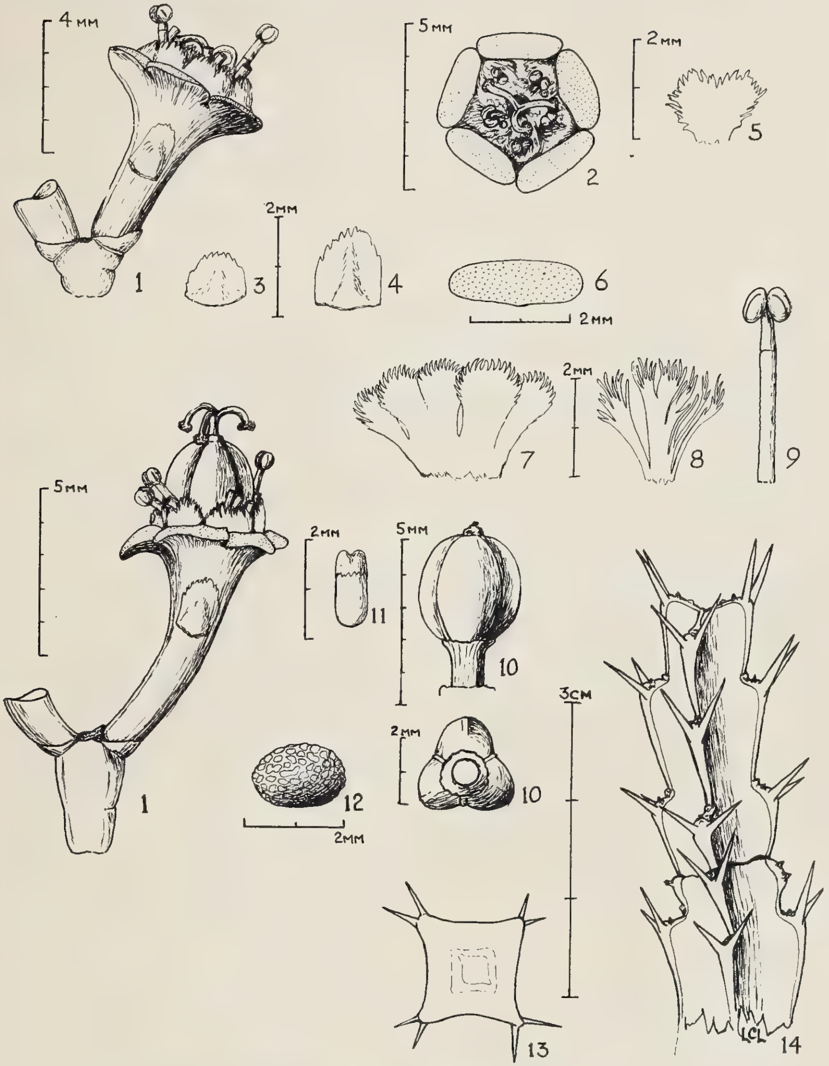


Plant at type locality.

The species has been found difficult to cultivate, possibly because it is virtually impossible to remove plants without causing extensive damage to the root system. The original gathering of live plants, made in 1961, died before flowering, but from those collected in the course of the expedition made in the following year, sufficient flowering and fruiting material was eventually obtained for this description to be completed.

Plant a spiny succulent ramulose pulvinate dwarf shrub, usually less than 15 cm. high. *Branches* and *branchlets* erect, rigid, crowded, quadrangular with the angles moderately compressed above and the sides only slightly concave below, tuberculate dentate, c. 1 cm. thick towards the truncate apices with the tubercle teeth more or less deltate, truncate or subtruncate, up to 2·5 mm. high, 8—12 mm. apart along the angles; main branches up to 17 cm. long with the subterete basal portion up to 2 cm. diam., tapering gradually towards the apex, not constricted into segments but the seasonal growth usually marked by curious fold-like divisions. *Spine shields* more or less linear—obtriangular, forming a continuous whitish horny margin, c. 1·5 mm. wide along the truncate upper slope of the tubercle teeth to just below the spine pairs, then narrowing to the flowering eye below. *Spines* relatively stout, up to 8 mm. long (generally about 5 mm.), in pairs at the apex of the tubercles, suberect to spreading, diverging but not very widely so (the included angle is usually c. 80°). *Leaves* minute (less than 1 mm. long) soon deciduous, leaving an inconspicuous scar flanked by a pair of minute prickles which are frequently obsolescent, then becoming little more than asperities. *Inflorescence* a shortly pedunculate cyme of 3 cyathia arranged in a plane at right-angles to the axis of the branch, produced from the axils of the tubercles c. 2·5 mm. behind the spine pairs; peduncle bibracteate, 1—3 mm. long; primary central cyathium male, deciduous; lateral bisexual cyathia usually held erect on curved bibracteate cyme branches, 1·75—4·5 mm. long; bracts ± ovate, c. 1·5 mm. long, emarginate, irregularly denticulate. *Involucre* glabrous, broadly funnel shaped, 3·5—5·25 mm. diam. 1·75—2·75 mm. long, with 5 transversely broadly elliptic, irregularly shortly fimbriate lobes c. 1·5 mm. long and 5 spreading, contiguous, transversely narrowly oblong glands 1·5—2·75 mm. in their greater diam., flat or slightly concave on the lightly pitted greenish yellow upper surface. *Male flowers* 25, produced successively; pedicels pink, c. 2·5 mm. long; filaments bright red; anther cells dark purplish red; bracteoles filiform fimbriate c. 2·5 mm. long; arranged in 5 fascicles each enclosed in a broad, flabellate, shortly fimbriate laciniate bract. *Pistillate flower* at first included in the involucre, very soon partially exserted; ovary 3-lobed trigonous; ovule attached beneath a denticulate fleshy hood. *Styles* 1—1·2 mm. long, free nearly to the base, purplish red, spreading recurved with entire or emarginate, capitate, rugulose translucent yellow apices. *Capsule* obtusely 3-lobed, partially exserted from the involucre, c. 3 mm. diam., 3·25 mm. high, blackish purple on the apex and down the angles and sutures, green below, borne on a lightly sulcate pedicel c. 1·5 mm. long, with a rudimentary perianth. *Seed* ellipsoid, somewhat flattened along the suture,

EUPHORBIA RAMULOSA



(1) Lateral bisexual cyathium.
(2) Involucre (in plan).
(3) Peduncular bract.
(4) Involucral bract.
(5) Involucral lobe.
(6) Involucral gland.
(7) Internal fascicular bract.
(8) Bracteole.
(9) Staminate flower.
(10) Capsule.
(11) Ovule with hood.
(12) Seed.
(13) Section through branch.
(14) Apical portion of branch.

c. 1·75 mm. long, 1·2 mm. diam., greyish brown, rather heavily verrucose with paler or somewhat whitish verrucae.

ACKNOWLEDGEMENTS

Dr. L. E. Codd, Chief, Botanical Research Institute, Pretoria, and his staff for the facilities of the Herbarium and their generous assistance in many directions.

Dr. E. A. L. Schelpe and Mr. R. Rutherford-Smith for their companionship and for much assistance in the field in the course of the two expeditions during which plants of *E. ramulosa* were collected.

Dr. H. Wild, Chief Botanist, Mr. R. B. Drummond and members of the staff of the Government Herbarium, Salisbury, for the Herbarium facilities and particularly for much taxonomic and nomenclatural advice.

EFFECTS OF MOLYBDENUM AND DIFFERENT SOURCES OF NITROGEN ON THE GROWTH AND CHEMICAL COMPOSITION OF *DIGITARIA SMUTSII* STENT

J. A. de Bruyn and J. Aalbers[1]

(*Department of Botany, University of Stellenbosch, Stellenbosch, South Africa*)

Abstract

Plants of *Digitaria smutsii* Stent (Northam ecotype) were grown in solution culture for 13 weeks with two sources of nitrogen, viz., nitrate and ammonium, both with and without molybdenum.

Plants supplied with nitrate plus Mo grew better than those without Mo, or than those supplied with ammonium. The dry weight of the shoots was by far the highest with nitrate plus Mo; there were no significant differences among the other treatments. Root growth was much better with nitrate than with ammonium, and was not affected by the presence or absence of Mo.

The concentration of nitrogen in the shoots tended to be lower with ammonium than with nitrate, and to decrease when Mo was withheld, although differences were not always significant. The N content of the roots was not significantly affected by Mo, but tended to be slightly lower with ammonium than with nitrate. When Mo was supplied, the Mo contents of the shoots and roots were significantly higher with ammonium than with nitrate as source of nitrogen.

The chlorophyll content of the leaves was the highest in plants supplied with nitrate plus Mo, and the lowest in those receiving nitrate only. With ammonium-N in the medium, Mo had no effect upon chlorophyll content.

In general, the levels of free amino acids in the shoots tended to be higher with ammonium than with nitrate in the medium. Alanine appeared to be the principal amino acid in both shoots and roots; it was not affected by nutrient treatment. Asparagine accumulated in shoots and roots when ammonium was supplied, but was absent in plants receiving nitrate. The levels of proline and serine were increased in the presence of Mo, regardless of the source of nitrogen.

Sucrose was present in plants receiving nitrate, but absent from those supplied with ammonium. In the presence of nitrate, glucose and fructose decreased when Mo was withheld, but in the presence of ammonium, Mo had the opposite effect.

It was concluded that *Digitaria smutsii* prefers nitrate to ammonium, and that it requires Mo for optimal growth in the presence of nitrate.

Introduction

Molybdenum has been shown to be essential for a wide range of plants, among which a number of grass species, e.g., *Avena sativa*, *Dactylis glomerata* and *Lolium perenne* (Hewitt, 1956; Stout and Johnson, 1956). This micronutrient element appears to be involved in the fixation of nitrogen in legumes (Mulder,

---

[1] Present address: Sea Point Boys' High School, Sea Point, Cape Town.

1948; Nason and McElroy, 1963), as well as in the reduction of nitrates to nitrites in plants (Nicholas and Nason, 1954; Evans, 1956).

Probably because of its role in the reduction of nitrate, a deficiency of Mo usually results in an accumulation of nitrates in plant tissues (Mulder, 1948; Agarwala and Hewitt, 1955a). Molybdenum may also affect other aspects of plant metabolism, e.g., the levels of the various free amino acids (Hewitt, Jones and Williams, 1949), the synthesis of chlorophyll (Hewitt and McCready, 1956), and the concentrations of ascorbic acid (Agarwala and Hewitt, 1955b) and sugars (Agarwala and Hewitt, 1955a) in plants.

The effects of a deficiency of Mo often appear to be less severe in plants receiving ammonium than in those supplied with nitrate (Hewitt, 1963). This is probably a consequence of its role in the reduction of nitrate. In general, however, plants seem to grow better with nitrate than with ammonium as the sole source of nitrogen, although many factors, e.g., the plant species, pH and aeration of the culture solutions may affect the relative merit of these two sources of nitrogen (Pardo, 1935).

Digitaria smutsii Stent is a perennial grass species which is sometimes used in pastures in South Africa. Relatively little is known about its mineral requirements; nothing is known about the effects of the different elements, particularly micronutrient elements, upon its metabolism. An investigation was therefore carried out to study the effects of molybdenum, in combination with two sources of nitrogen, viz., nitrate and ammonium, upon the growth and certain chemical constituents of this species.

MATERIAL AND METHODS

Seeds of *Digitaria smutsii* Stent, Northam ecotype, were germinated in acid-washed quartz sand and supplied with deionised water. When the seedlings were about 2 to 3 cm. tall, they were transferred to solution culture in 600 ml. polyethylene containers, aerated twice daily for one hour. Four treatments were applied, viz.; nitrate plus Mo; nitrate minus Mo; ammonium plus Mo; and ammonium minus Mo. All the nutrient solutions contained 140 ppm. of nitrogen. Six replicates of each treatment were used; they were arranged in randomised blocks.

The solutions were composed as follows:

Nitrate-nitrogen solution: 4 mM $Ca(NO_3)_2 \cdot 4H_2O$; 2 mM $CaCl_2$; 2 mM KNO_3; 1 mM K_2SO_4; 2 mM KH_2PO_4; 2 mM $MgSO_4 \cdot 7H_2O$.

Ammonium-nitrogen solution: 3 mM $CaCl_2$; 2·5 mM K_2SO_4; 2 mM $MgSO_4 \cdot 7H_2O$; 2 mM $(NH_4)_2SO_4$; 3 mM $(NH_4)_2HPO_4$.

In addition, each solution contained 1·1 ppm Fe (as NaFe-EDTA), 0·5 ppm B(as H_3BO_3), 0·5 ppm Mn(as $MnSO_4$), 0·05 ppm Zn(as $ZnSO_4 \cdot 7H_2O$), and

0·02 ppm Cu (as $CuSO_4 \cdot 5H_2O$). The respective plus-molybdenum solutions also contained 0·01 ppm Mo, as $H_2MoO_4 \cdot H_2O$. The pH of the solutions was adjusted to pH 6·5 with N NaOH.

In order to minimize contamination by molybdenum, all solutions were made up in Pyrex glassware and stored in polyethylene containers. Glassware was thoroughly cleaned in potassium dichromate-sulphuric acid solution and repeatedly rinsed, first with tap water and then with deionised water. Deionised water (tap water passed through a mixed-bed ion exchange column) was used in all solutions. Salts of the macroelements were purified of heavy metals by co-precipitation with cupric sulphate (Hewitt, 1952).

The plants were grown under conditions of natural daylength in a greenhouse maintained at a temperature not exceeding 30°C. All plants which failed to grow were replaced by others, until all were properly established. The experiment commenced on the 13th March, 1963; all plants were harvested at the age of 13 weeks. Nutrient solutions were renewed weekly for the first three weeks, and twice weekly after that. On intervening days the solutions were supplemented with deionised water.

At harvest time the tillers of each plant were counted. The aerial parts (shoots) and roots were then separated. Plants of four replicates were dried at 100°C for 48 hours and their dry weights determined. They were subsequently used for analyses of nitrogen and molybdenum. Plants of the remaining two replicates were placed in polyethylene bags and immediately stored in a freezer at −9°C; they were later used for the determination of chlorophyll, free amino acids, and sugars.

The nitrogen content of the plants was determined by the micro-Kjeldahl method (Humphries, 1956). Molybdenum was analysed according to the ammonium thiocyanate method (Prince, 1955); colour comparisons were made at 500 nm. with the aid of a Klett-Summerson photoelectric colorimeter. The chlorophyll *a* and *b* contents of the leaves were determined spectrophotometrically according to the method of MacKinney (1941), using a Beckman DB spectrophotometer.

Free amino acids and sugars were extracted from the shoots and roots by grinding 10 g. fresh material with sufficient absolute ethanol to give a final concentration of 80% ethanol, filtering and washing the residue with 50 ml. 80% ethanol. Chlorophyll and other pigments were removed from the leaf extracts by shaking the combined filtrate and washings with 200 ml. chloroform; the upper, aqueous layer was used.

Amino acids were removed from the extract by passing it through a column of Amberlite IR-120 resin (H^+ form). The amino acids were eluted from the resin with the aid of N NH_4OH, evaporated to dryness under reduced pressure at 40°C and the residue dissolved in 1·0 ml. 10% isopropanol. The solution which had passed through the column, and which contained the sugars and other materials, was also evaporated to dryness under reduced pressure at 40°C, the residue dissolved in 5 ml. redistilled pyridine at 100°C, filtered and again evaporated to dryness. The resulting residue was dissolved in 1·0 ml. 10% isopropanol.

The free amino acids were separated by means of two-dimensional descending chromatography on Whatman No. 1 paper, with phenol-water (80:20; v/v) as the first and 1-butanol- acetic acid- water (4:1:1; v/v) as the second solvent system. Their positions were located by spraying the chromatograms with 0·25% ninhydrin in acetone. The different amino acids were identified by comparison with standard charts, or by co-chromatography.

Sugars were separated by means of one-dimensional descending chromatography on Whatman No. 1 paper, with phenol-water (80:20; v/v) as solvent. They were located by spraying the chromatograms first with a solution of 2 ml. aniline plus 100 ml. ethyl acetate containing 2% trichloracetic acid, drying them at 80—85°C, and then spraying them with a 1% resorcinol solution. The different sugars were identified by comparing them with standard compounds on the same paper.

The relative concentrations of the different amino acids and sugars were estimated according to the size and intensity of the spots produced on the chromatograms, and graded into five groups, from 0 to 4.

The results obtained from the first four replicates (i.e., growth measurements and determinations of mineral content) were analysed statistically according to standard methods of analysis of variance (Snedecor, 1956). Results in respect of chlorophyll content and the levels of free amino acids and sugars were not statistically analysed.

RESULTS AND DISCUSSION

General observations on growth

All the plants supplied with nitrate were readily established, but considerable difficulty was encountered in establishing those plants receiving ammonium, particularly when Mo was withheld.

After two weeks the leaves of the plants receiving nitrate without Mo developed signs of chlorosis, which could not be alleviated by increasing the application of iron. After eight weeks these plants were markedly yellowish-green, in contrast to the dark green leaves of the plants receiving nitrate plus Mo. The plants receiving ammonium also appeared somewhat chlorotic. At this time (eight weeks) some leaves of all the plants began to show a reddish-purple discoloration, followed by progressive necrosis. This phenomenon was much more marked in the plants receiving ammonium than in those supplied with nitrate; it did not appear to be related to the supply of molybdenum.

In general, the plants receiving Mo seemed to grow better than those without Mo, particularly when they were supplied with nitrate. Plants supplied with nitrate appeared to grow better than those with ammonium; the roots of the former were healthy, white and much better developed than those of the latter treatment, which were yellowish-brown and rather spindly.

During the course of the experiment inflorescences developed only in four plants: two receiving nitrate plus Mo and two supplied with ammonium minus Mo. The latter two ears died without maturing. The poor development of ears might have been related to the fact that the experiment was carried out during the autumn. Apart from these, one could not distinguish any effects of treatment upon the development of the plants.

Growth results

Best growth of the shoots (in terms of dry weight as well as tiller production) occurred in the plants supplied with nitrate plus Mo, with no significant differences among the other treatments (Table 1). This means that the growth of plants supplied with nitrate was reduced when Mo was withheld, and when plants received a complete nutrient (i.e., including Mo) they grew better with nitrate than with ammonium. The shoot growth of plants supplied with ammonium was not affected by the presence or absence of Mo.

Agarwala and Hewitt (1955b), Hewitt and McCready (1956) and Minina (1960) found the dry weights of shoots of cauliflower, tomatoes and lettuce respectively to be increased upon the addition of Mo, regardless of the source of nitrogen. In the presence of Mo, all these authors obtained better growth with nitrate alone than with ammonium, but in the absence of Mo the yields were higher with ammonium than with nitrate. All three species (cauliflower, tomato and lettuce) gave the lowest yields in the presence of nitrate alone.

The differences between our results and those of the above mentioned authors might indicate that *D. smutsii* is more sensitive than cauliflower, tomato or lettuce to ammonium nitrogen. On the other hand, *D. smutsii* was grown in solution culture, whereas these plants were grown in sand or soil, which was probably better aerated, with the result that they might have been better able to utilise the ammonium.

Molybdenum had no significant effect upon root growth, regardless of the source of nitrogen (Table 1). Root growth both with and without Mo was much poorer with ammonium than with nitrate. These results are also reflected in the much higher top:root ratio in plants supplied with ammonium than with nitrate. The fact that, with nitrate as source of nitrogen, the absence of Mo retarded top growth but not root growth, is also reflected in the top:root ratios of the plus-Mo and minus-Mo treatments.

TABLE 1
Influence of nitrogen source and molybdenum upon number of tillers, dry weights of shoots and roots, and top/root ratio

Treatment		Number of tillers per plant	Dry wt. of shoots g	Dry wt. of roots g	Top/root ratio D. W. basis
Nitrate + Mo ..	..	120·5	37·8	7·0	5·5
Nitrate − Mo ..	..	80·8	11·4	6·3	1·8
Ammonium + Mo	..	87·5	10·9	0·8	13·6
Ammonium − Mo	..	72·5	10·0	0·7	14·3
L.S.D. (P = 0·05)	..	31·2	19·2	3·2	——a)

a) Not calculated.

The foregoing results indicate that *D. smutsii* prefers nitrate to ammonium as a source of nitrogen. In this respect it reacts similarly to barley, oats and rye (Pardo, 1935). Although the two nutrient solutions also differed in other respects than the source of nitrogen (i.e., the plants supplied with ammonium received less Ca and K, and more P, S and Cl than those supplied with nitrate), it is doubtful whether these differences in composition would have had an appreciable effect upon growth.

It further appears that, when nitrate is supplied, the plants respond to Mo, particularly where the growth of the shoots is concerned. The fact that *D. smutsii* responded to a lesser degree to Mo in the presence of ammonium, might probably be related to the role of Mo in the reduction of nitrate. In addition, the apparently deleterious effects of the ammonium treatment might have masked a possible response to Mo, since Hewitt (1963) has concluded that Mo might have a multiple role not yet fully elucidated.

Nitrogen and molybdenum contents

The effects of the different treatments on the nitrogen content of the shoots and roots are summarised in Table 2. Although the nitrogen concentration in the shoots tended to be higher where nitrate had been supplied than with ammonium, this difference was significant only in the presence of Mo. In plants receiving ammonium, the nitrogen concentration was lower with than without Mo. When nitrate was supplied, however, Mo had no significant effect upon the nitrogen content of the shoots. When one calculates the total nitrogen in the shoots, it is clear that the plants supplied with nitrate plus Mo contained the most nitrogen, and those receiving ammonium plus Mo the smallest total amount of nitrogen.

TABLE 2
Influence of nitrogen source and molybdenum on nitrogen content of shoots and roots

Treatment	N content of shoots		N content of roots	
	% of dry wt.	mg. per plant	% of dry wt.	mg. per plant
Nitrate + Mo	0·97	366	1·22	85
Nitrate − Mo	1·06	121	1·21	76
Ammonium + Mo	0·52	57	1·06	8·5
Ammonium − Mo	0·93	93	0·93	6·5
L.S.D. (P = 0·05)	0·18	——a)	0·27	——a)

a) Not calculated.

The nitrogen concentration in the roots of plants receiving nitrate tended to be higher than those with ammonium, but the differences were significant only in the absence of Mo (Table 2). Molybdenum itself had no significant effect upon the nitrogen content of the roots. The total nitrogen content of the roots, like that of the shoots, was considerably higher in the presence of nitrate than with ammonium; Mo probably had no significant effect in this respect.

It would appear, therefore, that the plants tended to absorb more nitrogen (per unit of dry weight) when supplied with nitrate than with ammonium, whereas Mo had no consistent effect upon the concentration of nitrogen in the tissues.

The nitrogen contents reported here represents only total nitrogen, and gives no indication of the nitrate content of the tissues. A number of authors, e.g., Agarwala and Hewitt (1955b) and Minina (1960) have found considerably more nitrate-nitrogen in plants supplied with nitrate in the absence of Mo than in its presence.

The effects of the different treatments upon the Mo content of the shoots and roots are summarised in Table 3. As could be expected, the addition of Mo resulted in considerable increases in Mo content. When Mo was withheld, the source of nitrogen had no effect upon the concentration of Mo, but with Mo in the medium the concentration of Mo in the tissues tended to be higher where ammonium had been supplied than with nitrate. The Mo level with any particular treatment was more or less the same in the shoots and in the roots; it was more or less the same as found in other members of the Gramineae under fairly similar conditions (Stout and Johnson, 1956).

TABLE 3
Influence of nitrogen source and molybdenum on molybdenum content of shoots and roots

Treatment	Mo content (μg/g dry wt.)	
	Shoots	Roots
Nitrate + Mo	0·05	0·06
Nitrate − Mo	0·01	0·01
Ammonium + Mo	0·07	0·08
Ammonium − Mo	0·02	0·01
L.S.D. (P = 0·05)	0·02	0·02

Chlorophyll content of the leaves

Although the results (Table 4) only represent the averages of duplicate determinations, it appears that the plants supplied with nitrate plus Mo had the highest, and those receiving nitrate without Mo had the lowest chlorophyll content. The high chlorophyll content of the former appears to result from increased levels of both chlorophyll *a* and *b*, with relatively more chlorophyll *b*. With nitrate as a source of nitrogen, a decreased supply of Mo therefore resulted

TABLE 4
Influence of nitrogen source and molybdenum on chlorophyll content of leaves (in mg. per g fresh material)

Treatment	Chlorophyll a	Chlorophyll b	Chlorophyll a + b	Ratio a : b
Nitrate + Mo	0·70	0·41	1·11	1·7
Nitrate − Mo	0·40	0·10	0·50	4·0
Ammonium + Mo ..	0·55	0·13	0·68	4·2
Ammonium − Mo ..	0·52	0·16	0·68	3·3

in reduced synthesis of both chlorophyll *a* and *b*. With ammonium in the medium, Mo apparently had no effect upon chlorophyll content. Hewitt and McCready (1956), Agarwala and Hewitt (1955b) and Minina (1960) also found that, with nitrate in the medium, absence of Mo resulted in a decreased level of chlorophyll in the leaves of tomato, cauliflower and lettuce, respectively. With ammonium however, Agarwala and Hewitt (1955b) and Hewitt and McCready (1956) found the chlorophyll content to be increased in the absence of Mo. On the basis of these results Hewitt and McCready (1956) concluded that Mo does not appear to be essential for chlorophyll formation in tomato or cauliflower, provided that nitrogen is available in a form that does not directly involve the mediation of nitrate reductase for its assimilation. Our results may be interpreted in the same way.

TABLE 5
Influence of nitrogen source and molybdenum on relative concentrations* of free amino acids in shoots and roots

Amino acid	Shoots				Roots			
	Nitrate-N		Ammonium-N		Nitrate-N		Ammonium-N	
	+ Mo	− Mo	+ Mo	− Mo	+ Mo	− Mo	+ Mo	− Mo
γ-Alanine	4	4	4	4	4	4	3	3
γ-Aminobutyric acid	1	1	2	1	2	1	1	1
Asparagine	0	0	3	3	0	0	2	2
Aspartic acid	3	1	2	3	3	1	2	2
Glutamine	1	1	0	0	1	1	1	1
Glutamic acid ..	2	1	4	4	3	0	3	3
Glycine	2	2	4	4	2	4	2	2
Leucine/isoleucine ..	1	1	3	1	1	1	1	1
Proline	1	0	2	1	1	0	1	0
Serine	1	0	3	1	3	0	3	1
Threonine	2	2	3	3	3	3	3	3
Valine	1	1	3	2	2	2	1	1

* Relative concentrations estimated according to size and intensity of ninhydrin spots, and graded from 0 to 4 as follows: 0—absent; 1—trace; 2—small spot; 3—medium-sized spot; 4—large and intensely coloured spot.

Amino acid content of shoots and roots

The relative amounts of free amino acids in the shoots and roots are listed in Table 5. Although these results are only semiquantitative, they do indicate certain trends. Most of the free amino acids in the shoots appear to have been present in higher concentrations with ammonium than with nitrate; in the roots the source of nitrogen did not seem to have much effect upon the free amino acids. α-Alanine appears to have been the principal amino acid in both shoots and roots; apparently it was not affected by either the nitrogen source or by molybdenum. Asparagine was present only in plants receiving ammonium nitrogen. Glutamine was absent from the shoots of plants receiving ammonium; otherwise it was present only in low amounts. Apparently neither of these two amides was affected by Mo. In the shoots of plants supplied with nitrate the levels of glutamic acid and aspartic acid appeared to decrease when Mo was withheld. Similar results were obtained by Hewitt and Williams (1952) in cauliflower and by Possingham (1956) in tomatoes. Proline and serine were lower in plants without Mo, regardless of the source of nitrogen; in those plants receiving nitrate without Mo they appeared to be completely absent. Steinberg (1956) also observed substantial decreases in the levels of proline and serine in tobacco plants supplied with nitrate and without molybdenum.

TABLE 6
Influence of nitrogen source and molybdenum on relative concentrations* of free sugars in shoots and roots

Sugar	Nitrate-N + Mo	Nitrate-N − Mo	Ammonium-N + Mo	Ammonium-N − Mo
		Shoots		
Fructose	4	1	1	2
Glucose	2	1	1	2
Sucrose	1	1	0	0
		Roots		
Fructose	3	2	1	4
Glucose	2	1	1	4
Sucrose	1	1	0	0

* For explanation, see subscript to Table 5.

Sugar content of shoots and roots

The levels of free sugars found in the plants are summarised in Table 6. Again, these results are only semiquantitative, but certain trends could be noted. Sucrose was absent from plants receiving ammonium, but present in those with nitrate. In plants receiving nitrate, the levels of glucose and fructose were apparently reduced in the absence of Mo, whereas the opposite effect was observed in plants supplied with ammonium. Agarwala and Hewitt (1955a) noted a decrease in the concentrations of total and reducing sugars in cauliflower plants suffering from a deficiency of molybdenum, irrespective of the source of nitrogen. As regards our own results, It is difficult if not impossible to offer a good interpretation of the effects of the different treatments upon the levels of the free sugars.

CONCLUSIONS

Although some of the results obtained were fairly variable—perhaps more replicates should have been used—they have shown that *D. smutsii* does not grow as well in solution culture with ammonium nitrogen as with nitrate, and that when nitrate is supplied molybdenum is required for optimal growth. The lack of response to molybdenum in the presence of ammonium might have been due to the limiting effects of ammonium on growth.

Apart from their effects on growth, the two sources of nitrogen also appear to affect the absorption of nitrogen and molybdenum, the synthesis of chlorophyll and the levels of free amino acids in the shoots. Asparagine seems to be the principal storage compound for amino nitrogen when ammonium nitrogen is supplied to the plants.

Although molybdenum affects the synthesis of chlorophyll in plants supplied with nitrate, this effect is probably indirect, since no response to molybdenum was obtained in plants receiving ammonium nitrogen. The levels of aspartic acid, glutamic acid, proline, serine, fructose and glucose were also affected by the presence or absence of molybdenum.

It is impossible to say which of the abovementioned effects of molybdenum and the nitrogen source upon the different constituents examined are direct effects and which are indirect.

ACKNOWLEDGEMENTS

This investigation was made possible by a grant from the South African Department of Agricultural Technical Services, for which we are most grateful.

The seed of *Digitaria smutsii* was kindly supplied by the Pasture Research Section of the Agricultural Research Institute, Potchefstroom.

REFERENCES

AGARWALA, S. C., & E. J. HEWITT (1955a). Molybdenum as a plant nutrient. V. The interrelationships of molybdenum and nitrate supply in the concentrations of sugars, nitrate and organic nitrogen in cauliflower plants grown in sand culture. *J. Hort. Sci.* **30**: 151—162.

Agarwala, S. C., & E. J. Hewitt (1955b). Molybdenum as a plant nutrient. VI. Effects of molybdenum supply on the growth and composition of cauliflower plants given different sources of nitrogen supply in sand culture. *J. Hort. Sci.* **30:** 163—180.

Evans, H. J. (1956). The role of molybdenum in plant nutrition. *Soil Sci.* **81:** 199—208.

Hewitt, E. J. (1952). Sand and Water Culture Methods used in the Study of Plant Nutrition. Commonwealth Bur. Hort. Plant. Crops, Techn. Commun. 22. East Malling.

Hewitt, E. J. (1956). Symptoms of molybdenum deficiency in plants. *Soil Sci.* **81:** 159—172.

Hewitt, E. J. (1963). The essential nutrient elements: requirements and interactions in plants. *In* F. C. Steward (Ed.) Plant Physiology. A Treatise. Vol. III, pp. 137—360. Academic Press, New York.

Hewitt, E. J., E. W. Jones & A. H. Williams (1949). Relation of molybdenum and manganese to the free amino acid content of the cauliflower. *Nature* **163:** 681—682.

Hewitt, E. J., & C. C. McCready (1956). Molybdenum as a plant nutrient. VII. The effects of different molybdenum and nitrogen supplies on yields and composition of tomato plants grown in sand culture. *J. Hort. Sci.* **31:** 284—290.

Hewitt, E. J., & A. H. Williams (1952). Unpublished results supplied by Hewitt (1963), p. 301.

Humphries, E. C. (1956). Mineral components and ash analysis. *In* K. Paech and M. V. Tracey (Ed.) Modern Methods of Plant Analysis. Vol. 1, pp. 468—502. Springer-Verlag, Berlin.

MacKinney, G. J. (1941). Absorption of light by chlorophyll solutions. *J. biol. Chem.* **140:** 315—322.

Minina, E. I. (1960). On the physiological role of molybdenum in plants. *Doklady Akad. Nauk SSSR* **130:** 461—464. (Translated in *Doklady Botanical Sciences* **130:** 32—35).

Mulder, E. G. (1948). Importance of molybdenum in the nitrogen metabolism of microorganisms and higher plants. *Plant & Soil* **1:** 94—119.

Nason, A., & W. D. McElroy (1963). Modes of action of the essential mineral elements. *In* F. C. Steward (Ed.) Plant Physiology. A Treatise. Vol. III, pp. 451—536. Academic Press, New York.

Nicholas, D. J. D., & A. Nason (1954): Molybdenum and nitrate reductase. II. *J. biol. Chem.* **207:** 353—360.

Pardo, J. H. (1935). Ammonium in the nutrition of higher green plants. *Quart. Rev. Biol.* **10:** 1—31.

Possingham, J. V. (1956). The effect of mineral nutrition on the content of free amino acids and amides in tomato plants. I. A comparison of effects of deficiencies of copper, zinc, manganese, iron and molybdenum. *Australian J. Biol. Sci.* **9:** 539—551.

Prince, A. L. (1955). Methods in soil analysis. *In* F. E. Bear (Ed.) Chemistry of the Soil. 1st Ed., pp. 346—347. Reinhold Publishing Corp., New York.

Snedecor, G. W. (1956). Statistical Methods. 5th Ed. Iowa State University Press, Ames.

Steinberg, R. A. (1956). Metabolism of inorganic nitrogen by plants. *In* W. D. McElroy and B. Glass (Ed.) Inorganic Nitrogen Metabolism, pp. 153—158. Johns Hopkins Univ. Press, Baltimore.

Stout, P. R., & C. M. Johnson (1956). Molybdenum deficiency in horticultural and field crops. *Soil Sci.* **81:** 183—190.

A NEW STAPELIAD FROM S.W. AFRICA

J. J. Lavranos

Stapeliopsis urnaeflora Lavranos. Nova species affinis *S. neronis* Pillans sed corolla minus globosa, structura coronae satis discedit.

Caules erecti vel ascendentes pro parte subterranei, quadragoni, angulis rotundatis, sinuato-dentatis, a 70 mm. longi, ca. 20 mm. diam., cani, fusco-brunnei maculati, ubique minute papillosuli; *folia* minuta, squamaeformia, mox decidua, *flores* 2—4 aggregati, ex parte inferiore caulium producti; *bracteae* deltoideae minusquam 1 mm. longae; *pedicelli* teretes, glabri, 6 mm. longi; *sepala* deltoidea 2 mm. longa, glabra; *corolla* urceolaris, 15 mm. longa, parte latiore 9 mm. diametiens, subtus orem a 5 mm. constricta; *tubus* a 12 mm. longus ad orem, intus, 2 mm. diametiens, ubique laete vinicolor; extus glaber, intus dense papillis brevibus obtectus; papillae in setam longam productae; *lobi* deltoidei, glabri erecti, basi 3 mm. lati, 3 mm. longi; *corona exterior* cupuliformis, 3 mm. diam., colonam staminalem non excedens, glabra, fusca vinicolor, lobis bifidis, segmentibus deltoideis, acutis; *coronae interioris* lobi adscendentes, stricti, complanati, apicibus rotundatis inter sese tangentibus.

Type Locality: South West Africa, Tiras Mountains, collected September, 1963 by W. Lofty-Eaton; Kennedy in Lavranos 2536, holytope (PRE), isotypes (K, HEID, GENEVA), fl. Bryanston, Johannesburg, March–April, 1965.

Description

Stems ascending or erect, in part subterranean, to 70 mm. long, 20 mm. diam., grey-green with brown spots, covered everywhere with minute papillae, 4-angled, the angles rounded with obtuse and laterally somewhat compressed teeth.

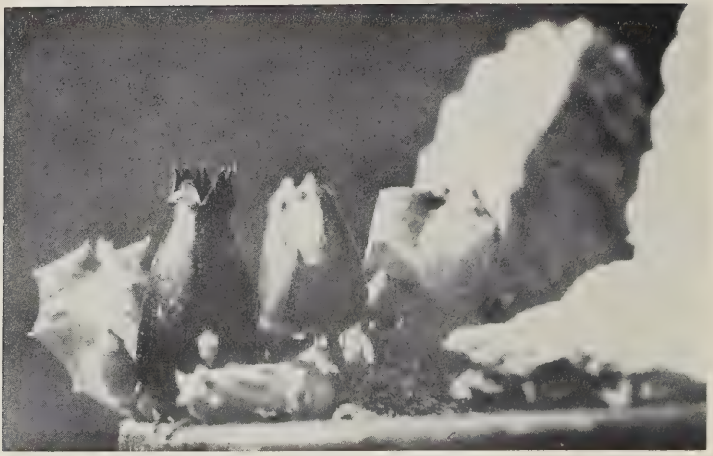
Leaves minute, scale-like, soon deciduous.

Flowers 2—4 together from the lower part of young stems, developed successively.

Bracts less than 1 mm. long, deltoid.

Pedicels terete, glabrous.

Corolla urceolate, 15 mm. long, 9 mm. diam. in its lower part, gradually constricted to 5 mm. below the mouth; *tube* to 12 mm. long, wine-coloured



S. urnaeflora Lavranos appr. x 2

on both sides, outside glabrous, inside densely covered with rounded papillae, each papilla, especially at base of tube, terminated by a long, stiff, simple hair, the mouth inside 2 mm. diam.; lobes deltoid, erect, glabrous 3 mm. broad at base 3 mm. long.

Outer corona 3 mm. diam., cup-shaped, slightly shorter than the staminal column, five-lobed, each lobe bearing 2 short, deltoid, acute, erect teeth, glabrous.

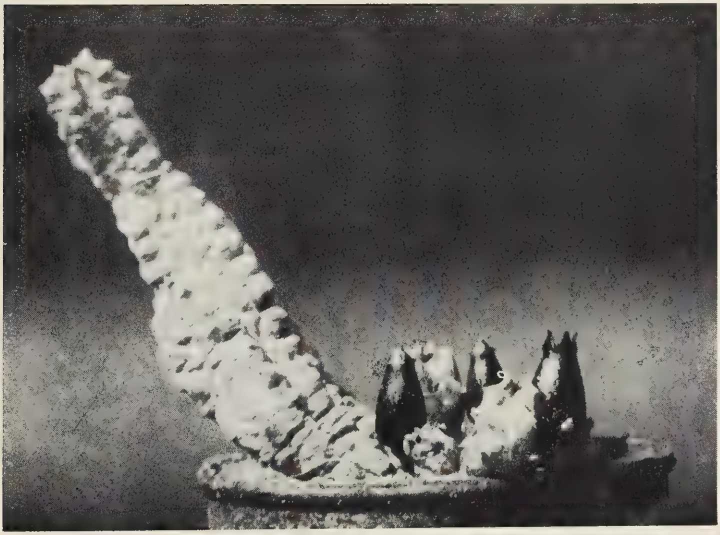
Inner corona lobes 2 mm. long, ascending-erect, with rounded apices, connivent in the centre above the staminal column.

This interesting plant was collected in the Tiras Mountains of South West Africa by Mr. W. Lofty-Eaton of Maltahöhe in September, 1963. Mr. Lofty-Eaton sent specimens to Mr. H. C. Kennedy of Bellville, Cape Province, from whom the present author obtained live material in Nov. 1963. Mr. Kennedy was struck by the unusual form and texture of the stems and expressed the opinion that they appeared to belong to the long-lost *Stapeliopsis neronis* Pillans. He proved to be essentially right in his diagnosis for, when the plants flowered in 1965, they were found to represent an unknown species of *Stapeliopsis* Pillans, a genus hitherto considered monotypic.

Our plants possess, in effect, an urceolate corolla, densely papillose within which, although more elongate than in *S. neronis*, does not differ from the latter in any essential characters.

The outer corona of *S. urnaeflora* differs considerably from that of its ally for, while in both species this organ is cupular in form, in *S. neronis* it is described as tubular and of a length such as to include the entire staminal column and to exceed it in height. This is not the case in our species, in which the outer corona scarcely attains the height of the staminal column. No major difference appears to exist between the inner corona lobes in the two species, but while in *S. neronis* they are subulate, erect and appr. 5 mm. long, in the new species they are only 2 mm. long, ascending-erect and connivent at the centre over the staminal column. In erecting the genus *Stapeliopsis*, Pillans chose as the distinguishing generic character the tubular form of the outer corona. Nothwithstanding this, and bearing in mind the great versatility and variety of floral form and detail in the genus *Caralluma* R.Br., Pillans' plant and the species now described could find a place within that genus.

Nevertheless, no species with an urceolate corona have so far been included in *Caralluma*. This type of corolla is, indeed, rare among the Stapelieae, being met with only in three species of *Echidnopsis* from East Tropical Africa (*E. urceolata* Bally, *E. watsonii* Bally, *E. ballyi* (Marnier-Lapostolle) Bally) and one from S.W. Arabia (*E. squamulata* (Dcne.) Bally). The four-angled stems prevent the inclusion of *Stapeliopsis neronis* and of the new species in *Echidnopsis*.



S. urnaeflora Lavranos natural size showing erect habit of flower.

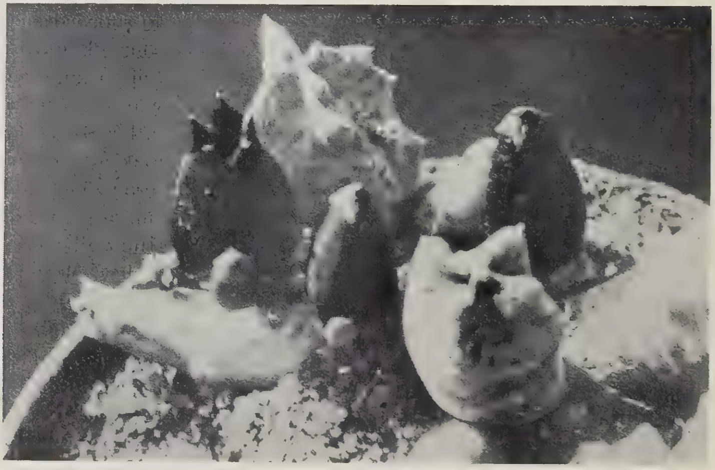
Although there would appear to exist a rather close relationship between *Stapeliopsis* Pillans and *Pectinaria* Haw., the two genera may be kept separated as the latter's main character rests in the connate apices of the corolla lobes.

The urceolate form of the corolla, combined with stems which are neither tesselate nor tuberculate, is then, in the present author's opinion, the principal character upon which the genus *Stapeliopsis* should be based, while the relative length of the outer corona should be considered simply a matter of degree. The above would, consequently, appear to be the only valid reason wherefore the species here described should not be attributed to *Caralluma* but rather to *Stapeliopsis*. Its inclusion renders necessary a somewhat broader definition of that genus for its corona is reduced in length so that it does not include the staminal column.

KEY TO THE GENUS STAPELIOPSIS

I.	Corolla urceolate, sub-globose; outer corona tubular, longer than the staminal column	*S. neronis*
II.	Corolla urceolate, elongate; outer corona cupular, shorter than the staminal column	*S. urnaeflora*

I am indebted to Mr. H. C. Kennedy of Bellville, Cape, for the plants of *S. urnaeflora*, much other plant material and his co-operation over a number of years.



S. urnaeflora Lavranos appr. x 2.

Mr. W. Lofty-Eaton of Maltahöhe, S.W. Africa for collecting plants of the new species.

Dr. L. E. Codd, Chief, Botanical Research Institute, Pretoria and his staff and Dr. R. A. Dyer, for their constant interest over many years, the use of the facilities of the National Herbarium and much other help.

Mr. F. Stayner, Curator of the Karroo Gardens, Worcester and Mr. Littlewood, Assistant Curator, have sent me living material, collected by Mr. Littlewood near Aus in S.W. Africa, which appears to belong to *S. urnaeflora*. I wish to thank them here for their consideration and express the hope that their plants will soon flower so that their identity might be established definitely.

NOTES ON MESEMBRYANTHEMUM AND ALLIED GENERA

H. M. L. Bolus

Jensenobotrya vanheerdei L. Bol. sp. nov.—Planta fera "in alio frutice supportata" (*van Heerde*); ramuli floriferi culti 3 visi, pallidi vel cum aetate albi, ad 6 mm. diam., internodiis 1·5—5 cm. longis; folia diu fere erecta, articulata, vagina subnulla, crassa politaque, marginibus carinaque ad lineam obscuram reductis, supra visa plana vel superne convexula, apice rotundo, lat. visa inferne leviter angustata, apice rotundo, lateribus convexis, glauce viridia vel partim roseo suffusa, ad 4 cm. longa, ad 1·4 cm. lata, prope medium latissima, ad 1·5 cm. diam.; flores irregulariter 2-ternati, cymosi, pedunculo cymarum 2·5—6 cm., florumque ad 1·5 cm., longo; receptaculum obconicum vel globose obconicum, 5—6 mm. longum, ad 6 mm. diam.; sepala 5, 6—8 mm. longa, basi 2—4 mm. lata, exteriora obtusa vel subacuta, interiora acute subulata, marginata; petala obtusa alba, 1·2 cm. longa, ca. 0·75 mm. lata; filamenta alba, antheris pollineque luteis; discus crenulatus, 5-angulatus, angulis obtusis; ovarii lobi acute compressi; stigmata 5, anguste subulata, longe caudate attenuata, saturate purpurea, ad 5 mm. longa; capsula pallida, infra globose obconica, 8 mm. longa, 8 mm., expansa ad 1·5 cm., diam.

Cape Province: Namaqualand; Richtersveld, Godas Beacon ("about 15 miles from Godas Mine"), in anno 1962, *P. van Heerde*. Fl. hort, Jan. 1966 Bolus Herbarium 27741.

This may be a cultivated form of **J. lossowiana** Herre. Imperfect flowers only were seen.

Mr. van Heerde writes that he found this plant in 1962, growing in another bush and being supported by it. The *green* leaves attracted his attention and he took slips for cultivation. One flower was produced in 1964 and another in 1965, the primary branches reaching 30 inches in length. In Jan. 1966 he describes a plant in his garden, "really needing support," having 5 primary branches up to 38 inches long, "with a cluster of the flowers at the end". In one of his tins "the branches try to support themselves."

Lampranthus mucronatus L. Bol. sp. nov.—Plantae 4 visae, compactae, sat rigidae, glabrae, ad 15 cm. altae, ad 22 cm. diam., caule ad 6 mm. diam.; rami

primarii ad 4 mm. diam.; ramuli hornotini 4—6-foliati, internodiis demum ad 2 cm. longis; folia primum fere erecta, deinde ascendentia, interdum leviter falcata, supra visa plana, e bene supra medium angustata, acute mucronata, mucrone cum aetate subspinescente, lateraliter visa prope apicem angustata, acuta carinata, saepius 2—3·5 cm. longa cum vagina ca. 5 mm. longa, medio ad 5 mm. lato, 4—6 mm. diam.; flores solitarii diurni, subsessiles vel pedunculi saepe ad 5 mm. longi, fructiferi 1—2·5 cm. longi, bracteis angustis, ad 9 mm. longis; receptaculum globose obconicum, 5—6 mm. longum, ad 9 mm. diam.; sepala 5, oblonge ovata vel oblonga, exteriora mucronulata, interiora marginata, 5—7 mm. longa, basi 3—5 mm. lata; petala ca. 3-seriata, ex infra medium angustata, obtusa vel subacuta, nivea, 1—1·5 cm. longa, ad 2·5 mm. lata; filamenta 5—6-seriata, glabra alba, antheris pollineque luteis; discus sat conspicuus, undatus, quasi e glandulis 5, connatis crenulatis compositus; lobi ovarii obtusi, vix compressi, altitudinem disci leviter excedentes; stigmata 5, gracilia, 5—6 mm. longa; capsula infra obconica, 5 mm. longa, ad 1 cm., expansa 1·6 cm., diam., supra fere plana, ad 1 mm. elevata, suturis leviter compressis, carinis divergentibus, medium valvae attingentibus, alis angustissimis.

Cape Province: in dit. Ceres; "15 Miles west of Skittery Kloof, where the road runs up from Gansfontein on the Ceres Karoo to join the one from Geido Pass to the Cedarberg/Algeria area," *F. J. Stayner*. Karoo Garden 998/61. Fl. Sept. 1965. Fruct. Nov. 1965. Of this second visit, 4 years later, to obtain fruiting material Mr. Stayner writes: "It took me a lot of searching to find the correct ridge, not visible from the road. It seems to be the only one on which this species occurs. It grew in profusion."

Ruschia densiflora L. Bol. sp. nov. (*Tumidula*).—Plantae 45 cm. altae, ad 120 cm. diam. (*H. Hall*); rami 6 visi, ad 39 cm. longi, internodiis saepius 4—5 cm. longis et 4—5 mm. diam.; folia ascendentia vel erecta, supra convexula acuta apiculata, dorso rotundo, 2·5—4·2 cm. longa cum vagina impresse lineata, 4—5 mm. longa; cymae densissime floriferae, ca. 3-trichotome ramosae, apice demum fere plano, saepius 10—14 cm. longae diametroque, pedunculo 4—5 cm. longo; pedunculi ultimi gracillimi, saepe ad 1 cm. longi, prope medium bracteati, bracteis saepe 4 mm. longis cum vagina 2 mm. longa; receptaculum subglobosum, ad 2 mm. longum, ad 3 mm. diam.; sepala 5, subaequilonga acuta, ad 3 mm. longa, basi 1·5—2 mm. lata, interiora late marginata, apice subulato; petala ca. 3-seriata, parum inaequilonga, e prope medium inferne leviter angustata, obtusa vel subacuta, pulchre lilacina, ad 6 mm. longa, ad 0·75 mm. lata; staminodia nulla; stamina ca. 4-seriata, erecta, omnino alba, ad 3 mm. longa, filamentis intimis parum infra medium papillatis; discus sat conspicuus, crenulatus; ovarii lobi obtuse compressi, ca. ad 0·5 mm. elevati; stigmata 5, anguste subulata, ca. 1·25 mm. longa; capsulae infra subglobosae, 3 mm. longae, 4 mm., expansae 7 mm., diam., supra per 2 mm. elevatae, suturis compressis, valvis prope apicem erectis, carinis superne late patentibus, ca. medium valvae attingentibus, tuberculo profunde posito, parvo.

Cape Province: in dit. Clanwilliam; "12 miles E. of Lambert's Bay on the road to Graafwater", Nov. 1965, *H. Hall* 3052. "About 18 inches tall, up to 4 ft. in diameter. Isolated groups of 6—10 specimens where the veld was undisturbed."

Delosperma gramineum L. Bol. sp. nov.—Planta fere erecta, in graminosis orta, glabra, copiose ramosa, cum floribus ad 20 cm. alta, ca. ad 25 cm. diam. vel ultra; radix lignosa, 2 cm. diam.; rami primarii breves, basi ad 4 mm. diam., secondarii ad 2 mm., hornotini saepe 0·5 mm., diam., gracillime graminei, internodiis 1—4 cm. longis; folia erecta vel ascendentia vel e medio recurva, semiteretia, supra lateraliterque visa acuta, viridia, 1—2 cm. longa cum vagina ca. 0·5 mm. longa, medio saepius ad 3 mm. lato diametroque; flores solitarii, inter minima in genere; pedunculi gracillimi, saepius 2—5 cm. longi; receptaculum obconicum, proper apicem leviter constrictum, 3 mm. longum, ad 4 mm. diam.; sepala 5, acuta inaequilonga, 3—6 mm., vel in fructu immaturo ad 8 mm., longa, basi 1·5—2 mm. lata, interiora late marginata; petala non bene visa, ca. 3-seriata, inferne leviter angustata, obtusa alba, 4—5 mm. longa, ca. ad 0·75 mm. lata; staminodia non visa; filamenta ca. 4 seriata, alba, antheris pollineque primum stramineis; glandulae conspicuae crenulatae; stigmata 5, angustissime subulata, 3 mm. longa cum cauda ca. 1 mm. longa; capsula infra obconica, pallida, 4 mm. longa, 6 mm., expansa 1 cm., diam., supra per 2 mm. elevata, suturis compressis, apice ringente.

Cape Province: in dit. Cradock; "summit of mountain, Mount Zebra National Park," Jan. 1966, *L. C. C. Liebenberg* 7657.

KEY TO THE GROUPS AND SUBGROUPS OF **Trichodiadema** (AMENDED).

1. Papillae tipped with a soft hair—e.g. *T. strumosum, T. fergusoniae* . .	STRUMOSA
1. Papillae not as above.	ESTRUMOSA
2. Leaves ± conspicuously tipped with bristles	SETIFERA
3. Bristles radiating to form a diadem	RADIANTIA
4. Plants low growing, densely compact or loosely branched —e.g. *T. densum, T. barbatum*	BARBATA
4. Plants with elongated virgate branches—e.g. *T. setuliferum, T. pomeridianum*	VIRGATA
3. Bristles erect, forming a tuft—*e.g. T. intonsum*	STRICTA
2. Leaves not, or very obscurely, tipped with bristles—*e.g. T. attonsum*	ATTONSA

NOTE.—The type specimens of all new species described in this paper are in the Bolus Herbarium, University of Cape Town.

(*To be continued*)

NOTES ON *CONOPHYTUM FICIFORME* (HAW.) N.E.BR. AND *CONOPHYTUM PLACITUM* (N.E.BR.) N.E.BR.

R. C. Littlewood

Report of field-observations made by F. J. Stayner and R. C. Littlewood during the month of June from 1960—1964

Area Surveyed. Divisions of Worcester, Robertson and Montagu. From 3 miles north to 5 miles north-west of Worcester, thence 7 miles north-east of Worcester (De Wet) and the southern foothills of the Hex River Mountains—K.G.418, 418a, 419, and 420/60.

The south-western foothills of the Rabiesberg and the Kwadouwberg—K.G.431, 432, 436, and 437/60.

Hills south of the road from Nuy to Robertson, including the farm 'Eilandia'—K.G.202/63.

The farm 'Dublin', south of the Breede River—K.G.382/61.

South of Robertson—K.G.433/60 and crossing the Breede River at this point—K.G. 434/60.

The foothills of Cogman's Kloof.

Habitat. Mainly in shale on karoid hills, except K.G. 433/60 and 382/61 which grew in Table Mountain Sandstone, although the soil was shale-like in appearance. Growing in crevices of rock out-crops at moderate heights, or flat ground covered with stones coated with lichens. Isolated colonies often found on the same hill, each assuming its own predominant variation, as in K.G. 418, 418a, (De Wet). Found at all points of the compass, in full sun or protected from the afternoon sun.

Growth. *Plants* glabrous, forming compact clumps, those growing on flat ground forming domes, those on shale out-crops forming more or less flat mats. Plants with red or green bodies growing together, either in shade or exposed positions—K.G. 433, 434/60 (Robertson).

Shape of the bodies variable—cordate, obconical, fig-shaped, sometimes truncate, as in K.G. 418a. (De Wet). Top of the body usually with a faint to strong ridge at right angles to the orifice, often forming a keel. The persistent sheaths of previous years crowded and papery.

Colouring variable—red, reddish-green, bright green, or yellowish to brownish green, and on the sides of the body reddish to green, sometimes with green translucent dots.

Markings variable—single scattered translucent green dots, or dots confluent into lines on the ridge and around the margin of the lobes, occasionally the green dots being superimposed by red raised dots. Markings often vary on the bodies of one plant.

The only stable characteristic is a line of translucent dots on the margin of the orifice, with a confused translucent area comprised of dots at each end of the orifice.

Flowers. *Calyx* herbaceous, segments 4.

Corolla variable in colour—white, white with pale pink tips, pale to dark pink, often having a white 'eye', the segments variable in length and width.

Stamens in several series.

Style short, red in dark pink corollas, yellowish green in paler corollas.

Colonies of pink-flowered plants occur north of Worcester and south of Robertson—K.G. 419, 420, 402, 434, 435, and 437/60.

Mixed colonies of specimens with white and pink flowers occur at the Karoo Garden—K.G. 331/60 and De Wet—K.G. 418/60.

White and pink flowers occur on the same plant on 6 specimens observed.

Flowering in June, opening in late afternoon, and very strongly scented, probably one of the strongest in the genus.

Conclusion. The numerous collections made and the extensive field-observations recorded have enabled us to state with confidence that **C. odoratum** (N.E.Br.) N.E.Br. **M. jugiferum** N.E.Br., **C. altile** N.E.Br. and **C. pallidum** N.E.Br. are forms of **C. ficiforme** (Haw.) N.E.Br. and should therefore, be included in that species (published in 1821).

Conophytum ficiforme (Haw.) N.E.Br. *C. odoratum* (N.E.Br.) N.E.Br.; *M. jugiferum* N.E.Br.; *C. altile* N.E.Br.; *C. pallidum* N.E.Br.

The collection, K.G. 418/60 (De Wet), agrees with the description of the typical form of **C. ficiforme,** whilst less than two feet away were plants of K.G. 418A/60 answering to the description of *C. odoratum* with pear-shaped bodies. *C. pallidum* is a pale-flowered form with a white centre, which was found in most collections.

In all the published descriptions the only characteristic found to be stable is not mentioned.

If Dr. N. E. Brown had only received one specimen of the extreme forms, he might in good faith have believed that each form grew on a hill of its own separated by a great distance, and not, as our recent field-survey has proved, that nearly every plant differs in the shape, size, colour and markings of the bodies, as well as in the shades of colour of the corolla, thus producing an infinite number of forms.

Conophytum placitum (N.E.Br.) N.E.Br. differs from **C. ficiforme** by its smaller growths, the corolla being much smaller and brush-like, with very narrow segments, and the expansion in the late evening.

It was collected on the farm 'Eilandia'—K.G. 202/63 and on the farm 'Dublin'—K.G. 382/61, both collections having yellowish flowers.

Conophytum placitum (N.E.Br.) N.E.Br. var. **pubescens** Littlew. var. nov.—Corpuscula omnino minute pubescentia vel inferne glabra.

Cape Province: in dit. Worcester; "growing freely on a koppie," June, 1961, *F. J. Stayner*. K.G. 382/61.

All plants examined have bodies completely and minutely pubescent at least on the apex, and in this respect differ from those of the typical form which were described as 'glabra'.

ACKNOWLEDGMENTS

My sincere thanks are due to Dr. L. Bolus for her invaluable guidance and assistance, to Professor H. B. Rycroft for taking photographs of Dr. N. E. Brown's type material at Kew, to Dr. A. Tischer for his assistance and living type material, and to Mr. F. J. Stayner for his ever generous co-operation and the careful observations he has made on his collections during the survey.

NOTES ON THE GENUS DELOSPERMA (*MESEMBRIEAE*)

M. Lavis

The first species of this genus was Aiton's very distinct **M. echinatum** published in 1789 and figured by Redoutè in de Candolle's Plantes Grasses.

In the early part of the nineteenth century this was followed by Haworth's **M. crassuloides, M. incomptum, M. testaceum** and **M. subincanum;** Salm Dyck's **M. ecklonis** and **M. asperulum;** Ecklon and Zeyher's **M. lehmannii;** and from 1872—1898 Regel's **M. abyssinicum** and Hooker's handsome pair, **M. sutherlandii** and **M. cooperi,** were followed by Schlechter's **M. nubigenum.**

In the twentieth century N. E. Brown's **M. mahonii,** Kensit's **M. litorale,** Berger's **M. brunnthaleri** and **M. cronemeyerianum,** Engler's **M. nakurense** and **M. oehleri** were added.

These constituted **Delosperma** N.E.Br., which was published in a key to the genera in 1925, and which was, therefore, incompletely described. The following description is derived from copious living material and many excellent drawings:—Plants perennial caespitose, compact, or loosely branched, erect or primary branches ascending, decumbent or rarely creeping, herbaceous or frutescent, "up to five feet in height", or with annual shoots from the subtuberous or woody rootstock; leaves terete, subterete and semiterete, or flat (linear, lanceolate, oblong-lanceolate, ovate-lanceolate, broadly ovate), rarely laterally compressed or acutely keeled; herbaceous parts glabrous or softly pubescent or rarely velvety, the papillae (except in **D. echinatum, D. longipes** and a few others) usually inconspicuous; flowers solitary or laxly cymose, diurnal, 2—7 cm. diam., peduncles 1—5 cm. long; receptacle obconic, semiglobose or rarely subclavate; sepals 5, or rarely 4 or 6; petals usually pluriseriate, obtuse or subacute, white, pale rose, purple-rose, rose-purple, yellow or rarely copper or reddish copper, or very rarely changing from red to bronze; staminodes nearly always present, appressed to the collected stamens, the innermost filaments papillate; nectary-glands very variable—distant, approximate, or rarely continuous; ovary concave or deeply concave or more or less elevated and lobed; stigmas 5 or rarely 4—6, usually subulate or slender, tapering to the apex or caudate; loculi of the capsule completely open or narrowly winged, the seeds fully exposed throughout.

The genus is very sparsely represented in the west. **D. asperulum** occurs in the Cape Peninsula and northwards in the south-western districts, **D. crassum** in Vanrhynsdorp, **D. hallii** and **D. pergamentaceum** in Namaqualand, and **D. ausense** and **D. klinghardtianum** in South West Africa. But the species gradually increase eastwards, reaching 54 in the Alexandria and Albany Divisions, and 94 between Port Elizabeth and the Lebombo Flats, and occur in all the floral regions of South Africa. Extending to Rhodesia are **D. mahonii, D. steytlerae** and **D. cooperi,** to Kenya, **D. oehleri** and **D. nakurense** and to Abyssinia, **D. abyssinicum.** The habitats range from the seashore to the summit of Mont aux Sources.

Delosperma now includes 140 species of which a large number may be divided into several more or less definite groups.—1. ANGUSTIFOLIA containing the species with the terete or subterete leaves. 2. PLANIFOLIA, the flat-leaved ones, subdivided into the glabrous and pubescent species. 3. CYMOSA, subdivided into the frutescent and the northern herbaceous species. 4. CARINATA (*Corpuscularia* and *Schonlandia*). 5. COMPRESSILATERA.

CYTOGENETIC STUDIES IN THE GENUS *ORNITHOGALUM* L.

II. KARYOTYPE ANALYSES IN SOME BIOTYPES OF *O. CONICUM* JACQ., *O. LACTEUM* JACQ., AND *O. THYRSOIDES* JACQ.[1].

T. J. Roos[2] and R. de V. Pienaar[3]

ABSTRACT

The karyotypes of twenty-four biotypes of *O. thyrsoides*, nine of *O. lacteum* and one of *O. conicum* were analysed. All the chromosomes could be identified on the basis of morphological characteristics. The species and biotypes investigated all had a diploid number of 12, the only exception being the *O. lacteum* forma nov. from Sutherland with $2n = 10$.

The latter karyotype, with its long metacentric chromosome bearing a satellite, was found to have resulted from a centric translocation between chromosomes II and III of the $2n = 12$ complement.

Although single polyploid plants were found in otherwise diploid populations, polyploidy played no evolutionary role in Leighton's *miniatum-maculatum* group of *Ornithogalum* species.

The results indicated that bar one exception no distinction between taxa could be based upon karyological differences. These results are discussed in the light of the present concepts regarding biosystematics.

INTRODUCTION

The karyotype is defined as the chromosome complement of a species, and is further characterized by the number, form and size of the chromosomes. The karyotype was early recognised as a definite species character, which is reasonably constant in most individuals of a population; departures from the species pattern is attributed largely to recognisable aberrations (Swanson, 1957).

As pointed out by Stebbins (1950) and others, cytology became an accepted and exceedingly useful science in the hands of the taxonomist who was interested in something more than simple morphological criteria for defining species relationships. In fact, relationships within natural groups of species can scarcely be considered complete, in an evolutionary sense, without reliable cytotaxonomic information to reinforce conclusions based on morphological criteria.

Babcock (1942), Clausen (1940, 1951), Stebbins (1950), Turesson (1925) and others stressed the causal role of factors such as the degree of inbreeding, structure of the population, apomixis, number and form of the chromosomes, environmental variation, and introgressive hybridization, in the pattern of evolutionary divergence.

---

[1] Part of thesis submitted by the senior author in partial fulfilment of the requirements for the degree of M.Sc. in Agriculture at the University of Stellenbosch.

[2] Fruit and Food Technology Research Institute, Stellenbosch.

[3] Dept. of Genetics, S.E. College of Agriculture, Stellenbosch.

Lewis (1955) revealed that the amount of gene exchange between individuals is dependant upon the number and form of the chromosomes, thus creating a more objective criterion for the grouping of individuals into taxonomic categories.

The aim of the current investigation was to collect detailed karyological data of some species and biotypes in the genus *Ornithogalum* L., to ascertain its usefulness in a biosystematic study. Special attention was paid to the chromosome number and morphology, such as the position of primary and secondary constrictions.

MATERIALS AND METHODS

The following species, forma (according to the classification of Leighton, 1944/45) and biotypes were investigated:

O. thyrsoides Jacq. biotypes from:
Bokbaai; Citrusdal; Clanwilliam;
Darling; Durbanville; Elsenburg;
Gordons Bay; Jonkershoek; Kirstenbosch;
Cape Town; Kruisfontein, Knysna;
Leipoldtville; Malmesbury; Melkbosstrand;
Porterville; Paleisheuwel; Riviersonderend;
Sandveld; Stellenbosch; Swellendam;
Welgevallen, Stellenbosch.
O. thyrsoides Jacq. forma η biotypes from:
Calvinia, Kamieskroon, Springbok.
O. thyrsoides Jacq. forma ι biotype from:
Grahamstown.
O. lacteum Jacq. biotypes from:
Aurora, Darling, Duikerfontein,
Clanwilliam, Elandsbaai, Graafwater,
Pakhuispas, Vredendal.
O. lacteum Jacq. forma nov. biotype from:
Sutherland.
O. lacteum Jacq. forma β (= *O. synanthifolium*) biotype from:
Grahamstown.
O. conicum Jacq. biotype from:
Nieuwoudtville.

The localities mentioned are indicated on the map in fig. 1.

The biotypes were all morphologically distinct even after being grown under the same environmental conditions.

The bulbs were allowed to root in damp soil, and the young root tips cut at approximately 11.00 a.m. They were fixed and treated according to the schedule of Pienaar (1955).

The technique of Östergren and Heneen (1962) was also tried, but gave inferior results in the current material.

Idiograms were constructed after drawing the chromosomes at a magnification of 3,800 × by means of a "Carl Zeiss" drawing apparatus, and the three parameters, described below, were taken into account.

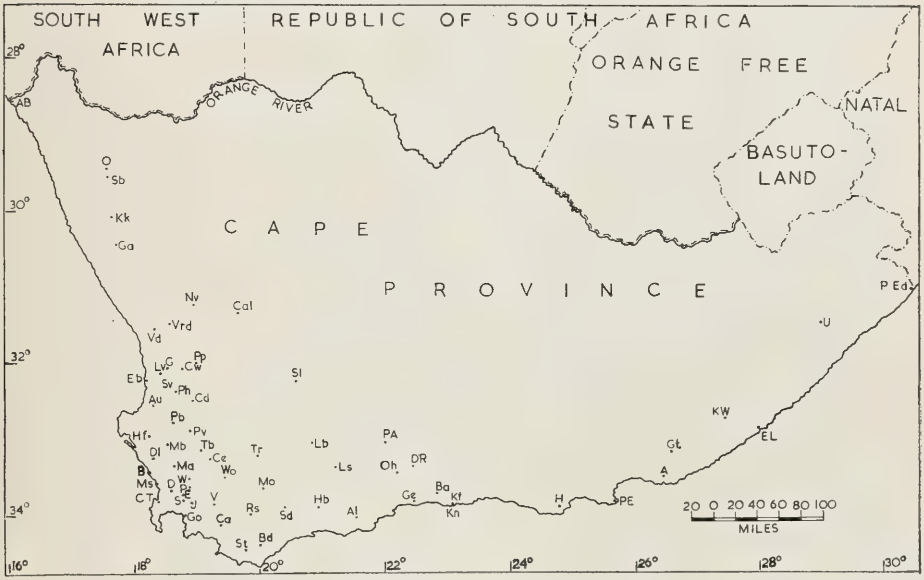
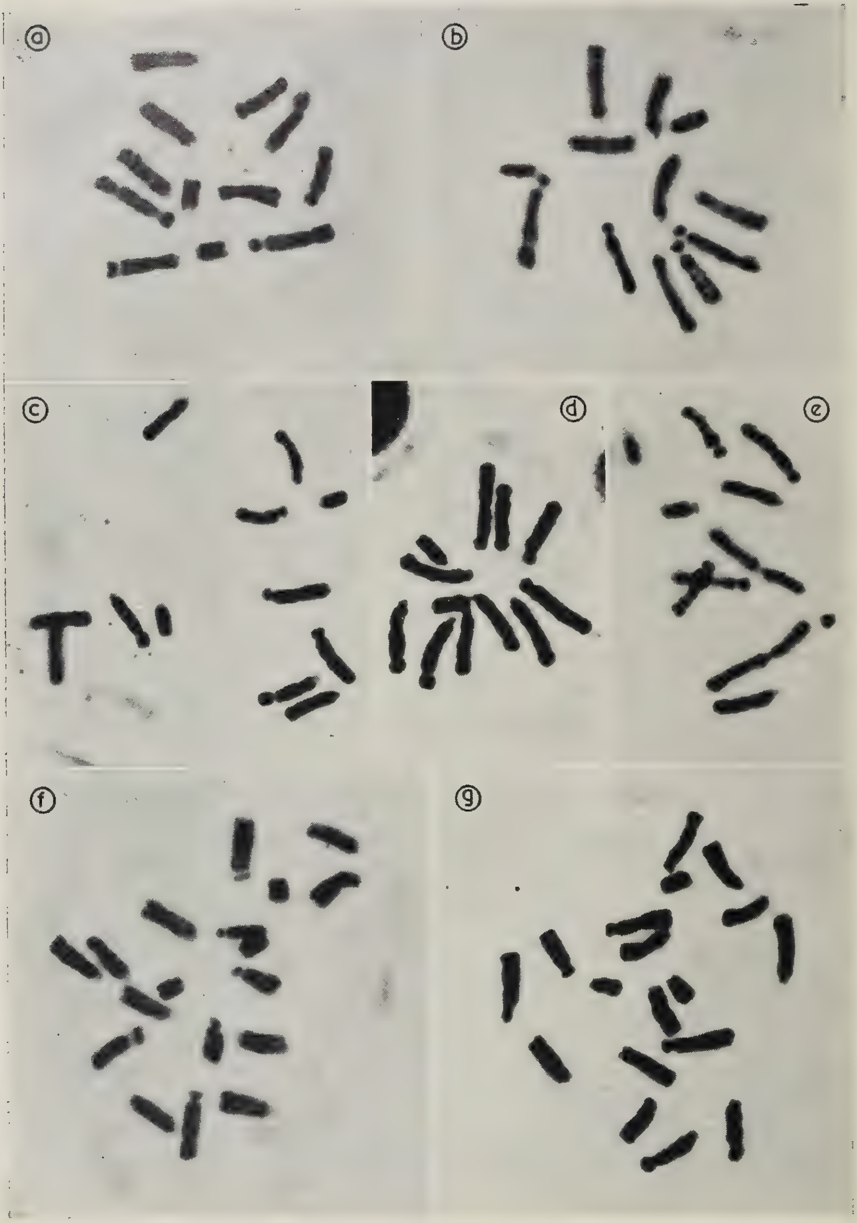


FIG. 1.

Map of the Cape Province indicating the localities where the various species and biotypes mentioned in the text were collected.

A—Alexandria; *AB*—Alexander Bay; *Al*—Albertinia; *Au*—Aurora; *B*—Bokbaai; *Ba*—Barrington; *Bd*—Bredasdorp; *Ca*—Caledon; *Cal*—Calvinia; *Cd*—Citrusdal; *Ce*—Ceres; *CT*—Cape Town; *Cw*—Clanwilliam; *D*—Durbanville; *Dl*—Darling; *DR*—De Rust; *E*—Elsenburg; *Eb*—Elandsbaai; *EL*—East London; *G*—Graafwater; *Ga*—Garies; *Ge*—George; *Go*—Gordons Bay; *Gt*—Grahamstown; *H*—Humansdorp; *Hb*—Heidelberg; *Hf*—Hopefield; *J*—Jonkershoek; *Kf*—Kruisfontein; *Kk*—Kamieskroon; *Kn*—Knysna; *KW*—King William's Town; *Lb*—Laingsburg; *Ls*—Ladismith; *Lv*—Leipoldtville; *Ma*—Malmesbury; *Mb*—Moorreesburg; *Mo*—Montagu; *Ms*—Melkbosstrand; *Nv*—Nieuwoudtville; *O*—Okiep; *Oh*—Oudtshoorn; *P*—Paarl; *PA*—Prince Albert; *Pb*—Piketberg; *PE*—Port Elizabeth; *PEd*—Port Edward; *Ph*—Paleisheuwel; *Pp*—Pakhuispas; *Pv*—Porterville; *Rs*—Riviersonderend; *S*—Stellenbosch; *Sb*—Springbok; *Sd*—Swellendam; *Sl*—Sutherland; *St*—Stanford; *Sv*—Sandveld; *Tb*—Tulbagh; *Tr*—Touwsrivier; *U*—Umtata; *V*—Villiersdorp; *Vd*—Vredendal; *Vrd*—Vanrhynsdorp; *W*—Wellington; *Wo*—Worcester.


a
b
c
d
e
f
g

OBSERVATIONS

A total of 24 biotypes of *O. thyrsoides* Jacq. were investigated. All were found to have a diploid chromosome number of 12 (Fig. 2*a* — *c*; Fig. 3·1 — 3·24). Sporadic triploids were found in natural populations, e.g. one of a group of plants collected at a locality near Grahamstown (Fig. 2*f*).

Nine biotypes of *O. lacteum* Jacq. were similarly investigated and with only one exception, all proved to be normal diploids with $2n = 12$ (Fig. 2*d*; Fig. 3·25 — 3·33). Triploid plants also occur in natural populations as exemplified by a single plant, in a large collection from Pakhuispas, which had 18 somatic chromosomes (Fig. 2*g*).

The most interesting exception to the $2n = 12$ karyotype was found in the *O. lacteum* forma nov. biotype from Sutherland, with a chromosome number of $2n = 10$ (Fig. 2*e*; Fig. 3—33). This karyotype probably arose from a centric fusion (due to a translocation in the centromere region) between two long acrocentric chromosomes, since the length of the resultant metacentric chromosome was almost double that of the larger acrocentrics in the usual $2n = 12$ karyotype (see detailed explanation below).

O. conicum Jacq., like *O. thyrsoides* and *O. lacteum* had a somatic chromosome number of 12 (Fig. 3·34).

Idiograms of the haploid chromosome complements of the species and biotypes investigated, are presented in fig. 3.

Minor variations in chromosome lengths, arm ratios and secondary constrictions were detected, and in this respect a detailed study was undertaken in order to ascertain whether significant differences exist between biotypes and species.

In Table I the absolute lengths of chromosomes are given in μ.

DEDUCTIONS

From Table I, as well as from the idiograms in fig. 3, it is clear that the basic set is $x = 6$, and that it is fairly similar in the different species and biotypes. All the chromosomes are almost acrocentric (rod shaped) with slight differences in the length of the short arms. Chromosomes I, II, IV, V and VI can be dis-

---

FIG. 2.

(*a–g*) C=metaphase plates from root tip cells of some *Ornithogalum* species and biotypes: (*a*) *O. thyrsoides* from Elsenburg; (*b*) *O. thyrsoides* from Jonkershoek; (*c*) *O. thyrsoides* forma η from Kamieskroon; (*d*) *O. lacteum* from Elandsbaai; (*e*) *O. lacteum* forma nov. from Sutherland; (*f*) *O. thyrsoides* forma ι from Grahamstown, triploid plant; (*g*) *O. lacteum* from Pakhuispas, triploid plant. All figures × 2,000.

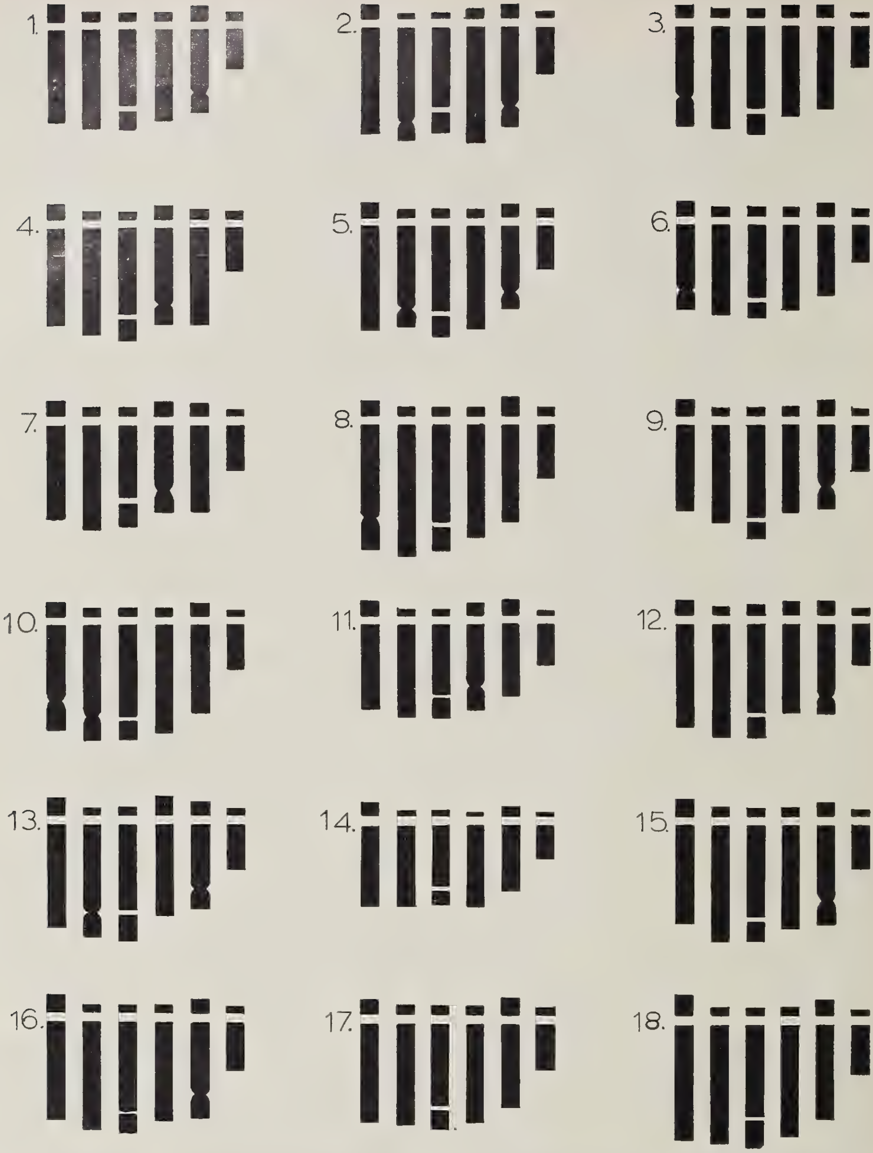
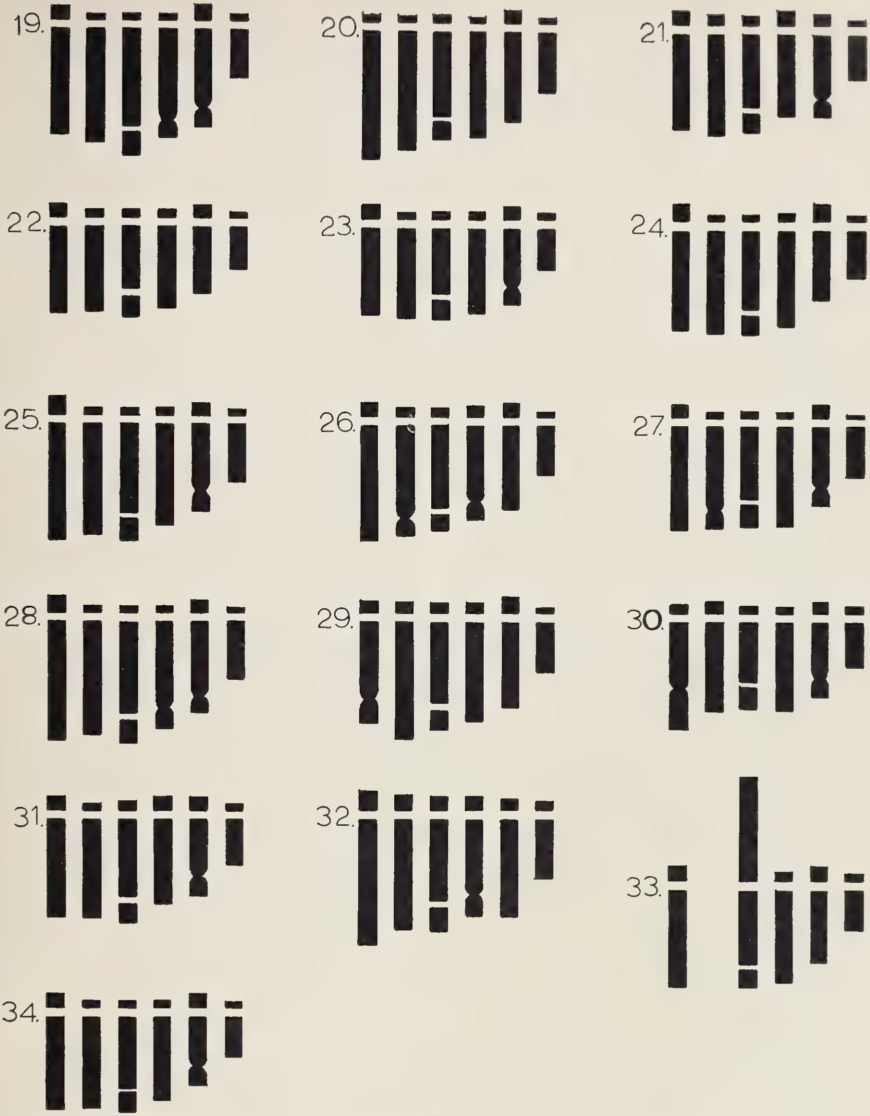


FIG. 3.

Idiograms of the haploid chromosome complements of different *Ornithogalum* species and biotypes (× 3,000)

1—20 *O. thyrsoides* Jacq. from:

1. Bokbaai
2. Citrusdal
3. Clanwilliam
4. Darling
5. Durbanville
6. Elsenburg
7. Gordons Bay
8. Jonkershoek
9. Kirstenbosch
10. Kruisfontein
11. Leipoldtville
12. Malmesbury
13. Melkbosstrand
14. Paleisheuwel
15. Porterville
16. Riviersonderend
17. Sandveld
18. Stellenbosch



19. Swellendam 20. Welgevallen
21—23 *O. thyrsoides* Jacq. forma η from:
21. Calvinia 22. Kamieskroon 23. Springbok
24. *O. thyrsoides* Jacq. forma ι from Grahamstown.
25—31. *O. lacteum* Jacq. from:
25. Aurora 26. Darling 27. Duikerfontein
28. Elandsbaai 29. Graafwater 30. Pakhuispas
31. Vredendal
32. *O. lacteum* Jacq. forma β(= *O. synanthifolium*) from Grahamstown.
33. *O. lacteum* Jacq. forma nov. from Sutherland.
34. *O. conicum* Jacq. from Nieuwoudtville.

TABLE I

AVERAGE LENGTHS OF CHROMOSOMES IN μ

Species and Localities	Chromosomes						Number of Cells
	I	II	III	IV	V	VI	
O. thyrsoides, Jacq.							
Bokbaai	5·3	5·2	5·0	4·8	4·8	2·3	17
Citrusdal	5·5	6·0	5·2	5·8	6·1	2·6	10
Clanwilliam	5·5	5·3	5·5	5·2	4·8	2·2	9
Darling	5·6	5·5	5·3	5·4	5·3	2·4	10
Durbanville	5·9	5·5	5·5	5·5	4·9	2·5	11
Elsenburg	4·8	4·8	4·8	4·6	4·2	2·1	8
Gordons Bay	5·3	5·3	5·1	4·8	4·7	2·4	15
Jonkershoek	8·2	7·0	6·4	6·1	5·7	2·9	10
Kirstenbosch	5·1	5·0	5·4	4·7	4·9	2·4	9
Kruisfontein	5·9	5·9	5·6	5·6	4·8	2·5	8
Leipoldtville	4·8	4·8	4·6	4·8	4·2	2·1	6
Malmesbury	6·1	6·0	5·8	5·2	5·1	2·3	17
Melkbosstrand	5·8	5·7	5·8	5·5	4·9	2·3	10
Paleisheuwel	4·8	4·3	4·0	4·4	3·7	1·9	3
Porterville	5·8	5·8	5·8	5·7	5·6	2·5	10
Riviersonderend	5·6	5·6	5·5	5·2	5·2	2·6	8
Sandveld	5·6	5·3	5·4	5·1	4·9	2·4	10
Stellenbosch	6·6	6·3	5·9	5·9	5·5	2·7	10
Swellendam	6·1	6·0	6·3	5·7	5·6	2·6	10
Welgevallen	6·7	6·3	5·7	5·6	5·1	3·4	10
O. thyrsoides, Jacq. forma η							
Calvinia	5·5	5·5	5·1	4·8	4·8	2·5	9
Kamieskroon	5·0	4·7	4·5	4·4	4·0	2·3	10
Springbok	5·1	4·9	4·7	4·6	4·5	2·3	12
O. thyrsoides, Jacq. forma ι							
Grahamstown	5·9	5·5	5·3	5·2	4·2	2·6	10
O. lacteum, Jacq.							
Aurora	6·6	5·9	5·9	5·3	5·0	3·0	10
Darling	6·3	5·7	5·2	4·8	4·1	2·6	7
Duikerfontein	6·0	5·2	5·0	5·1	4·5	2·7	10
Elandsbaai	6·6	5·9	6·0	5·6	5·3	3·0	10
Graafwater	6·5	6·1	5·5	5·3	5·0	2·8	10
Pakhuispas	5·6	5·1	4·5	4·6	4·4	2·6	5
Vredendal	5·6	5·1	5·1	4·8	4·3	2·6	8
O. lacteum, Jacq. forma β							
Grahamstown	7·0	6·2	5·9	5·6	5·5	3·4	10
O. lacteum Jacq. forma nov.							
Sutherland	5·5	—	9·7	4·9	4·2	2·2	10
O. conicum, Jacq.							
Nieuwoudtville	5·3	4·8	4·6	4·4	4·1	2·2	6

tinguished by means of differences in arm ratios while chromosome III, which is similar in length to chromosome II, is characterized by having a satellite. Chromosome VI is very short and can easily be recognised.

It is evident from Table I that the Jonkershoek biotype has considerably longer chromosomes than any of the other biotypes and is almost a third longer than those from Elsenburg and Leipoldtville. This phenomenon is probably due to genetic differences, as in *Lolium perenne* (Thomas, 1936), *Lathyrus odoratus* (Upcott, 1937) and *Matthiola incana* (Lesley and Frost, 1927), where recessive mutants were reported to influence the spiralization of the chromosomes—a less compact spiralization producing a larger chromosome. In Table II it can be seen that the relative length of the Jonkershoek biotype corresponds closely to that of all the other biotypes, indicating that the difference in length is a regular feature of the whole chromosome complement.

Because the chromosomes of the C-metaphase plates of different cells in the same root tip exhibit variable degrees of contraction, and furthermore, due to presumed genetic differences, the chromosomes of the various biotypes are contracted to different degrees, the relative chromosome lengths (explained below) are generally considered more reliable for comparative purposes than absolute chromosome lengths.

Due to the absence of readily detectable differences between three of the chromosomes, the following parameters, as defined by Ford *et al.* (1960), were investigated to aid in the placement of the chromosomes in the idiograms.

A: The length of each chromosome relative to the total length of a normal haploid set, expressed as a percentage.

B: The arm ratio of the chromosomes expressed as the length of the longer arm relative to the shorter one.

C: The centromere index, expressed as the ratio of the length of the shorter arm to the whole length of the chromosome per 100.

Ford (1960) and his co-workers (A Human Chromosomes Study Group) used these parameters in describing the human karyotype. In Table II these parameters with corresponding letters are represented for all the different species and biotypes.

Table II proved very useful when comparing the different chromosomes of a complement, and the complements of the different biotypes, forma and species. It is obvious that little variation exists between the respective chromosomes of the different biotypes, forma and species. During evolutionary divergence the chromosomes of this group of species remained fairly constant. Of the small amount of karyotypic variation that does exist, there is as much between biotypes of a species as there is between species.

By means of Table II it was possible to determine which chromosomes were involved in the centric fusion, resulting in a metacentric chromosome, during the evolution of the $2n = 10$ karyotype of the *O. lacteum* forma nov. from Sutherland.

TABLE II

QUANTITATIVE PROPERTIES OF MITOTIC CHROMOSOMES IN *ORNITHOGALUM* L. (SEE TEXT FOR THE MEANING OF SYMBOLS A, B AND C).

SPECIES AND LOCALITIES	CHROMOSOMES																	
	I			II			III			IV			V			VI		
	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
O. thyrsoides Jacq.																		
Bokbaai	19	5·5	15	19	15·5	6	18	13·6	7	18	12·2	8	18	5·6	15	8	6·2	14
Citrusdal	19	7·8	11	19	27·3	4	17	21·1	5	20	20·2	5	17	6·4	14	8	9·9	9
Clanwilliam	19	8·4	11	19	15·9	6	19	12·0	8	18	7·2	12	17	6·8	13	8	11·1	8
Darling	19	6·6	13	19	18·8	5	18	16·6	6	17	13·1	7	19	6·9	13	8	8·0	11
Durbanville	20	7·5	12	18	16·3	6	19	15·1	6	18	17·7	5	17	6·4	13	8	8·4	11
Elsenburg	19	6·9	13	19	17·3	6	19	13·0	7	18	10·7	9	17	5·3	16	8	7·8	11
Gordons Bay	19	6·4	13	20	12·9	7	18	11·2	8	17	8·0	11	18	9·8	14	9	9·2	11
Jonkershoek	20	8·3	11	20	21·0	5	18	16·4	6	17	18·2	5	16	6·0	14	8	8·3	11
Kirstenbosch	18	6·1	14	19	18·8	5	20	17·6	5	17	15·3	6	18	6·2	14	8	9·1	10
Kruisfontein	20	7·0	13	20	19·6	5	19	18·4	5	18	18·2	5	16	7·4	12	8	9·3	10
Leipoldtville	19	6·4	14	19	17·3	6	18	16·6	6	19	8·1	11	16	4·9	17	8	8·0	11
Malmesbury	20	6·8	13	20	11·9	8	19	12·9	7	16	6·6	13	17	6·4	14	8	7·8	11
Melkbosstrand	19	8·0	11	20	23·8	4	19	21·0	5	18	5·2	16	16	5·7	15	8	8·9	10
Paleisheuwel	20	5·6	15	19	16·3	5	17	15·2	6	19	15·0	6	16	5·6	15	8	6·6	13
Porterville	18	6·1	14	20	19·7	5	19	20·9	5	18	12·8	7	18	7·1	12	8	8·5	11
Riviersonderend	19	6·6	13	19	20·2	5	19	20·0	5	17	18·3	5	18	6·5	13	9	8·1	11
Sandveld	20	7·2	12	19	19·4	5	19	16·0	6	18	18·6	5	17	5·9	15	8	9·1	10
Stellenbosch	20	6·4	14	19	22·9	4	19	22·4	4	18	17·7	5	17	6·2	14	8	10·3	9
Swellendam	19	7·0	13	19	21·7	4	20	17·1	5	18	18·9	5	17	7·1	12	8	10·1	9
Welgevallen	20	20·3	5	19	20·9	5	17	15·7	6	17	20·4	5	16	7·6	12	10	13·2	7
O. thyrsoides Jacq. forma η																		
Clavinia	20	7·0	12	20	11·3	8	18	10·4	9	17	6·0	14	17	6·9	13	9	8·6	10
Kamieskroon	20	7·2	12	19	15·4	6	18	12·1	8	18	12·9	7	16	5·8	15	9	10·0	9
Springbok	20	5·7	15	19	17·5	5	18	12·6	7	18	13·5	7	17	5·6	15	9	7·9	11
O. thyrsoides Jacq. forma ι																		
Grahamstown	21	7·0	13	19	20·0	5	18	19·0	5	18	16·8	6	15	4·6	18	9	8·8	10
O. lacteum Jacq.																		
Aurora	21	6·8	13	19	16·2	6	19	19·2	5	17	12·6	7	16	6·3	14	9	10·2	9
Darling	21	7·9	11	19	15·7	6	18	14·2	7	16	5·8	15	17	7·4	12	9	9·0	10
Duikerfontein	21	6·9	13	18	17·1	6	18	14·9	6	18	14·2	7	16	5·9	15	9	9·2	10
Elandsbaai	21	7·1	12	18	[illegible]	5	18	16·5	6	18	14·4	7	16	6·1	14	9	10·3	9
Graafwater	18	9·4	10	20	14·3	7	18	12·1	8	18	11·8	8	16	6·0	14	9	9·6	9
Pakhuispas	19	6·5	13	21	14·3	7	17	12·1	8	17	15·0	6	16	5·1	16	10	8·8	10
Vredendal	20	7·2	12	19	16·7	6	19	16·7	6	18	5·9	15	15	5·8	15	9	8·8	10
O. synanthifolium Leighton (= *O. lacteum* Jacq. forma β																		
Grahamstown	21	7·6	12	19	7·7	11	18	8·3	11	16	5·1	16	17	7·4	12	10	8·8	10
O. lacteum Jacq. forma nov.																		
Sutherland	21	6·5	13				37	1·7	4	19	10·7	9	16	4·9	17	8	7·2	12
O. conicum Jacq.																		
Nieuwoudtville	21	6·2	14	19	17·3	6	18	17·5	6	17	15·6	6	17	4·7	18	9	7·5	12

In comparing the chromosomal parameters in Table II it can be noted that all the *O. lacteum* biotypes with $2n = 12$ have a relative length of approximately 21 for chromosome I. The *O. lacteum* forma nov. (Sutherland) chromosome that has a relative length of 21 is thus probably chromosome I. Similarly chromosomes IV, V and VI occur in the karyotypes of all the *O. lacteum* biotypes including the forma nov. from Sutherland. The relative lengths of chromosomes II and III of the typical *O. lacteum* biotypes are approximately 19 and 18, respectively, and presumably they underwent centric union to produce the metacentric chromosome of the Sutherland forma which has a relative length of 37. The fact that chromosome III of the typical *O. lacteum* biotypes as well as the metacentric chromosome of the forma from Sutherland possess a satellite, is additional evidence in support of this assumption. Figure 4 illustrates how the presumed translocation could have taken place to give rise to the new karyotype.

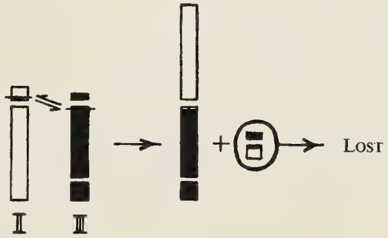


FIG. 4.

Diagram to illustrate how, by centric fusion, chromosome II and III of the primitive *Ornithogalum* complement gave rise to the long metacentric chromosome with a relative length of 37, in the karyotype of the *O. lacteum* forma nov. from Sutherland.

Column A of Table II gives an indication as to the proportional contribution of the different chromosomes to the whole complement. According to Swanson (1957) this is an important criterion in estimating the evolutionary position of a taxon, since a decrease in the chromosome number is correlated with evolutionary progress in many plant species.

Column B provides a measure of the symmetry of the chromosomes. The larger the figure in the column, the more asymmetrical are the chromosomes. The symmetry of the different chromosomes of one karyotype can be compared by reading the table horizontally while those of the different species and localities can be compared by reading the table vertically.

Column C gives the ratio of the short arm to the total length of the chromosome expressed as a percentage. Although there is an algebraic relationship between B and C, both are given, because C gives additional information about chromosome symmetry.

In the case of *O. thyrsoides*, a statistical analysis was made of the biotypes from 24 localities. A two way table (Table III) was compiled and in it the mean lengths of the chromosomes are presented as single observations. The least significant difference (L.S.D.) was calculated for the means of the chromosomes as well as for the localities, and are given at the foot of the Table.

TABLE III.

CHROMOSOME LENGTHS OF DIFFERENT BIOTYPES OF *O. THYRSOIDES*, (MEASURED IN MILLIMETRES AFTER IT WAS DRAWN AT A MAGNIFICATION OF 3,800 ×)

Localities	Chromosomes						Mean
	I	II	III	IV	V	VI	
Bokbaai	20·3	19·8	19·0	18·5	18·4	8·6	17·4
Calvinia	20·9	20·9	19·4	18·2	18·1	9·6	17·9
Citrusdal	20·6	22·6	19·9	22·1	23·3	9·8	19·7
Clanwilliam ..	20·7	20·3	20·8	19·7	18·0	8·5	18·0
Darling	21·4	21·0	21·1	20·5	20·3	9·0	19·0
Durbanville	22·2	20·7	20·9	20·6	18·6	9·4	18·7
Elsenburg	18·4	18·3	18·1	17·5	15·8	7·9	16·0
Gordons Bay ..	20·1	20·0	19·5	18·2	18·1	9·2	17·5
Grahamstown ..	22·4	21·0	20·0	19·6	16·1	9·8	18·2
Jonkershoek ..	27·0	26·4	24·3	23·0	21·6	11·2	22·3
Kamieskroon ..	18·9	18·0	17·0	16·7	15·0	8·8	15·7
Kirstenbosch ..	19·5	19·0	20·5	18·9	18·8	9·1	17·6
Kruisfontein ..	22·6	22·4	21·3	21·1	18·4	9·3	19·2
Leipoldtville ..	18·4	18·3	17·6	18·1	15·8	8·1	16·1
Malmesbury ..	23·0	22·9	22·2	19·9	19·3	8·8	19·4
Melkbosstrand ..	22·0	21·8	22·0	20·6	18·7	8·9	19·0
Paleisheuwel ..	18·3	16·5	15·4	16·7	14·3	7·2	14·7
Porterville	22·2	22·0	21·9	21·7	21·1	9·5	19·7
Riviersonderend ..	21·4	21·2	21·0	19·9	19·8	10·0	18·9
Sandveld	21·3	20·4	20·4	19·6	18·6	9·1	18·2
Springbok	19·5	18·5	17·7	17·4	17·1	8·9	16·5
Stellenbosch ..	25·2	23·9	23·4	22·4	20·9	10·2	21·0
Swellendam	23·1	22·7	23·9	21·9	21·1	9·9	20·4
Welgevallen ..	25·6	24·1	21·7	21·4	19·7	12·8	20·9
Mean	21·6	20·9	20·4	19·8	18·5	9·3	

L.S.D. for chromosome means = ·50 with P = ·05
= ·65 with P = ·01
L.S.D. for locality means = 1·0 with P = ·05
= 1·3 with P = ·01

From these calculated data Table IV was drawn up which gives an analysis of variance between biotypes and between chromosomes within biotypes.

TABLE IV.

ANALYSIS OF VARIANCE OF CHROMOSOME LENGTHS OF DIFFERENT BIOTYPES OF *O. THYRSOIDES*

Components of Variation	Degrees of Freedom	Sum of Squares	Mean Squares	Variance Ratio (F)
Localities	23	426·16	18·53	24·06**
Chromosomes	5	2523·50	504·70	655·45**
Error	115	88·32	·77	—
Total	143	3037·9	—	—

**P 0·01

The difference between chromosomes I and II is 0·7, which is significant. Between II and III, and III and IV the difference is only significant at the P = 0·05 level, and between IV and V, and V and VI the differences are again significant.

Chromosomes II and III differ from one another by the fact that one bears a satellite. The latter was taken as chromosome III.

By these means it was possible to distinguish all six of the chromosomes.

This study furthermore revealed that no distinction could be made between the typical *O. thyrsoides* biotypes and the *O. thyrsoides* formas on the basis of karyological characteristics.

From a comparison of the means and standard deviations which were calculated from Table I, it is also evident that on karyotypical grounds alone no distinction can be made between *O. thyrsoides*, *O. lacteum* and *O. conicum*.

DISCUSSION AND CONCLUSIONS

Like all systematic characters, the karyotype is subject to variation. In general, a particular karyotype can be designated as representative of the species, and in some instances even of the genus. In certain genera of the *Liliaceae* and in the North American species of *Tradescantia* the same karyotype is representative of an assemblage of species, while in *Crepis*, *Drosophila*, the lizards and the grasshoppers, the number, form and size of chromosomes vary widely from species to species (cf. Swanson, 1957).

The species of *Ornithogalum* in the present investigation showed a considerable degree of karyotypic resemblance. The statistical analyses indicate that no distinction can be drawn between biotypes and formas of *O. thyrsoides*, or between different species on the basis of karyological differences. This is in good agreement with the findings of Stebbins (1950) for the family *Liliaceae*, of which *Ornithogalum* constitutes a genus.

Further information regarding crossability, meiotic studies of hybrids, and the primitiveness or specialisation of morphologic characters, etc., are needed for a sound natural classification of the species.

With a few rare exceptions such as the *O. lacteum* forma nov. from Sutherland, and the triploid and tetraploid plants in otherwise diploid populations, all plants of the species and biotypes investigated had a chromosome number of 12. This is in agreement with the results of Pienaar (1963).

According to de Wet (1957), most of the chromosomes of *Ornithogalum* are metacentric, while the current study and that of Pienaar (1963) revealed that all the chromosomes are acrocentric, that is, have subterminally located centromeres. The chromosome numbers for some species listed by de Wet (1957), are also at variance with the results of Pienaar (1963).

Swanson (1957) is of the opinion that there is no direct connection in either the plant or the animal kingdom between basic number and phylogenetic position of families and higher ranks of classification. Though differences may be apparent between phyletic groups, no obvious trends can be correlated with primitiveness or with specialisation unless such correlations are made within the much narrower limits of family and particularly genus. At this level, a general tendency towards reduction in basic number is an indication of specialisation. The members of the family or genus with the lowest chromosome numbers can, therefore, often be considered more specialised.

Aneuploidy and polyploidy undoubtedly play a very important role in the evolution of the karyotype. According to Stebbins (1950) polyploidy is more common in the plant kingdom. The older more primitive members have lower chromosome numbers.

Pienaar (1963) pointed out that polyploidy played no part in the origin and evolution of the *miniatum-maculatum* group of species in Leighton's (1945) taxonomic list of the *Ornithogalum* species.

When only changes in basic number are involved, and the posibility of polyploidy definitely excluded, the major problem is one of determining the mechanisms leading to such change. A theoretical means of accomplishing this end was suggested by Darlington (1937). The scheme proposed was that gain or loss of chromosomes from a basic set involves gain or loss of centromeres, and that the success of such change depends upon whether the chromatin adjacent to the centromere is inert (heterochromatin) or active (euchromatin). Reciprocal translocations, with at least one of the breakage points being in inert regions, can transfer euchromatin to a centromere carrying only intert chromatin. (A B-type chromosome would serve this purpose). In this manner a chromosome can be added. Euchromatin can also be transferred from one chromosome to another, with loss of the depleted and now inert centric chromosomal regions, thereby reducing the number.

The latter mechanism is thought to have taken place in the case of the *O. lacteum* forma nov. from Sutherland with $2n = 10$. From a comparison of the arm lengths of all the *O. lacteum* biotypes it could be concluded that during the evolution of the Sutherland forma a translocation took place between chromosomes II and III of the normal basic set, resulting in a long metacentric chromosome and a short fragmented chromosome, which was lost (Fig. 4).

Aneuploid alteration was carefully studied in the genus *Crepis* (Babcock and Cameron, 1934; Babcock, Stebbins and Jenkins, 1937, 1942; Babcock and Jenkins, 1943; Babcock, 1942, 1947) and it was concluded that the more primitive species have a higher basic number. The evolutinary trend has thus been towards a reduction in chromosome number.

Whether these trends also apply to the tribus *Scilleae* to which *Ornithogalum* belongs, cannot be confirmed at this stage. The basic chromosome number of *Ornithogalum* varies from $x = 3$ to $x = 9$ (Pienaar, 1963). Two closely related genera namely *Scilla* and *Urginea* possess a basic complement of $x = 4$ up to $x = 11$, and $x = 5$ respectively. It is thought that the primitive haploid number of *Ornithogalum* is $x = 6$ and that both a reduction and an increase had taken place during the course of evolution.

Together with changes in chromosome number, changes in the relative form and size of chromosomes are of considerable importance in a study of the karyotype.

Levitsky (1931b) made a very intensive study of the karyotypes of the family *Ranunculaceae* and concluded that a symmetrical karyotype is more primitive, and that asymmetry is correlated with specialisation. According to Stebbins (1950) a karyotype is symmetrical when the chromosomes are of approximately equal length and metacentric or submetacentric. Asymmetrical karyotypes consist of chromosomes with subterminal centromeres or large differences in lengths, or both.

The investigations of Babcock, Stebbins and Jenkins (1937), Babcock and Jenkins (1943), and Babcock (1947) in the genus *Cichoreae* of the family *Compositeae*, confirmed Levitsky's hypothesis. The morphologically unspecialised species all possess symmetrical karyotypes. Stebbins (1950) believed that the family *Liliaceae* has the greatest diversity of karyotypes found within one family. The more asymmetrical examples are found among the more specialised species.

From the present study and that of Pienaar (1963) it is evident that the South African species belonging to the genus *Ornithogalum* also possess karyotypes composed only of acrocentric chromosomes, many of which are markedly different in length.

In respect to these findings it appears that *Ornithogalum* must be fairly specialised, due to its reasonably asymmetrical karyotypes.

On these grounds it might be argued that the Sutherland biotype of *O. lacteum* forma nov., which possesses the metacentric chromosome, is a relic with a more primitive karyotype. However, this biotype is adapted to the more severe and specialised environmental conditions of Namaqualand, whereas most of the typical biotypes of *O. lacteum* grow in the milder regions of the South Western Cape. Its growth habit also appears to be slightly more specialised. Therefore this biotype is probably not a primitive relic, but must be regarded as a specialised form of *O. lacteum*, or another morphologically similar species. Its karyotype of $2n = 10$, although it mimics a more primitive condition, may consequently also be regarded as more evolved.

The tendency towards a symmetrical karyotype in the Sutherland forma of *O. lacteum* must be considered exceptional in *Ornithogalum*, because according to Swanson (1957) the presumed centric union which led to the formation of the metacentric chromosome is a rare event in higher plants although a rather common mechanism in karyotypic evolution in animals.

ACKNOWLEDGEMENTS

The authors are indebted to the Dept. of Agricultural Technical Services for making this study possible.

REFERENCES

A HUMAN CHROMOSOMES STUDY GROUP (FORD, C., *et al*), 1960. A proposed standard of nomenclature of human mitotic chromosomes. Supplement to "*Cerebral Palsy Bulletin*", Vol. 2 (3).

BABCOCK, E. B., 1942. Systematics, cytogenetics and evolution in *Crepis*. *Bot. Rev.*, **8:** 139–190.

BABCOCK, 1947. The Genus *Crepis*, part II. The taxonomy, phylogeny, distribution and evolution of *Crepis*. Univ. Calif. Press, Berkeley.

BABCOCK, E. B. & CAMERON, D. R., 1934. Chromosomes and phylogeny in *Crepis* II. The relationship of 108 species. *Univ. of Calif. Publ. Agric. Sci.*, **6:** 287–324.

BABCOCK, E. B. & JENKINS, J. A., 1943. Chromosomes and phylogeny in *Crepis* III. The relationships of 113 species. *Univ. of Calif. Publ. Bot.*, **18:** 241–292.

BABCOCK, E. B. & STEBBINS, G. L., 1938. The American species of *Crepis*. Their relationships and distribution as effected by polyploidy and apomixis. *Carnegie Inst. Wash. Publ.*, **504:** 1–200.

BABCOCK, E. B., STEBBINS, G. L. & JENKINS, J. A., 1937. Chromosomes and phylogeny in some genera of the *Crepidineae*. *Cytologia*, Fujii Jubil. Vol.,: 188–210.

Babcock, E. B., Stebbins, G. L. & Jenkins, J. A., 1942. Genetic Evolutionary processes in *Crepis. Am. Nat.*, **76:** 337–363.

Clausen, J., 1940. Experimental studies on the nature of species I. Effect of varied environments on the western North American plants. *Carnegie Inst. Wash. Publ.*, **520:** 1–452.

Clausen, J., 1951. Stages in the Evolution of Plant Species. Hafner Publ. Co., New York.

Darlington, D. C., 1937. Recent Advances in Cytology. Churchill, London.

De Wet, J. M. J., 1957. Chromosome numbers in the *Scilleae. Cytologia*, **22:** 145–159.

Leighton, F. M., 1944. A revision of the South African species of *Ornithogalum* L. Part I. *Journ. S. Afr. Bot.*, **X:** 83–110.

————, 1944. Part II. *Journ. S. Afr. Bot.*, **X:** 111–122.

————, 1945. Part III. *Journ. S. Afr. Bot.*, **XI:** 135–189.

Lesley, M. M. & Frost, H. B., 1927. Mendelian inheritance of chromosome shape in *Matthiola. Genetics*, **12:** 449–460.

Levitsky, G. A., 1931. The karyotype in systematics. *Bull. Appl. Bot. Gen. Pl. Breed.*, **27:** 220–240.

Lewis, H., 1955. Specific and infraspecific categories in plants. Biological systematics. *Proc.* 16*th Ann. Biol. Coll. Oregon State College, Corvallis*, 13–20.

Östergren, G. & Heneen, W. K., 1962. A squash technique for chromosome morphological studies. *Hereditas*, 48.

Pienaar, R. de V. 1955. Combinations and variations of techniques for improved chromosome studies in the *Gramineae. Journ. S. Afr. Bot.*, **XXI:** 1–9.

Pienaar, R. de V., 1963. Sitogenetiese studies in die genus *Ornithogalum* L. I. Inleidende oorsig. *Journ. S. Afr. Bot.*, **XXIX:** 111–131.

Roos, T. J., 1964. 'n Sitogenetiese studie in die genus *Ornithogalum* L. M.Sc. thesis, University of Stellenbosch.

Stebbins, G. L., 1950. Variation and Evolution in Plants. Columbia Univ. Press. N.Y.

Swanson, C. P., 1957. Cytology and Cytogenetics. Prentice-Hall, Engelwood Cliffs.

Thomas, P. J., 1936. Genotypic control of chromosome size. *Nature*. **138:** 402.

Turesson, G., 1925. The plants species in relation to habitat and climate. *Hereditas*, **6:** 147–236.

Upcott, M., 1937. Timing unbalance at meiosis in the pollen sterile *Lathyrus odoratus. Cytologia*, Fujii Jub. Vol.: 299–310.

JOURNAL
OF
SOUTH AFRICAN BOTANY
VOL. 32

Published: 1st July, 1966

NOTES ON MESEMBRYANTHEMUM AND ALLIED GENERA

H. M. L. Bolus

Argyroderma litorale L. Bol. sp. nov. (*Roodia*).—Folia fere erecta vel ascendentia, divergio 1·5—3 cm. longo, supra apud apicem rotunda, lateraliter visa rotunda vel rarissime oblique subacuta, 4—6·5 cm. longa cum vagina 1·5—2·5 cm. longa, ad 1·3 cm. lata, 1—1·9 cm. diam.; pedunculi 1·4—3·3 cm. longi, parum supra basim bracteati; bracteae obtusae, 1·2—1·9 cm. longae; receptaculum ad 7 mm. longum, non, vel rare, apicem foliorum attingens; sepala 6—7, obtusa vel subacuta, omnia ± marginata, 4—5 mm. longa, basi 4—5 mm. lata; petala circa 4-seriata, inferne non, vel vix, angustata, saepius obtusa, lutea, 5—15 mm. longa, vix ad 1·25 mm. lata; stamina albida, 3 mm. longa; pulvinus stigmatiferus circa ad 3 mm. diam.

Cape Province: in dit. Vanrhynsdorp; Papendorp, "at the mouth of the Olifants River," *H. Hall.* N.B.G. 604/57. Fl. Jul. 1962.

This is the first species of **Argyroderma** to be recorded from the sea-coast.

Astridia alba L. Bol. sp. nov.—*A rubra* (L. Bol.) L. Bol. var. *alba* L. Bol., in vol. XXVII: 170 (Jul. 1961)—Rami 2 visi, stricti, 26 cm. et 14 cm. longi, internodiis 2—3·5 cm. longis, ad 7 mm. diam.; folia ascendentia, supra anguste lanceolata, acuta vel rare obtusa, lateraliter visa prope apicem angustata, apice leviter recurvo, ad 5 cm. longa, 1·2 cm. lata, 1·3 cm. diam., eis bracteas subtendentibus 2—3·5 cm. longis; bracteae variabiles, lateraliter visae acutae vel acuminatae, semi-ovatae vel oblique ovatae vel lanceolatae, margine rare obscure emarginato, 1—2 cm. longae; flores 5—6·2 cm. diam.; receptaculum obconicum, ad 5 mm. longum, ad 9 mm. diam.; sepala exteriora obtusa vel subacuta, 9—12 mm. longa, basi 5—6 mm. lata, interiora obtusa, superne obtuse subulata, 8—10 mm. longa, basi 3—6 mm. lata; petala sat laxa, ca. 4-seriata, inferne e prope medium leviter, vel vix, angustata, obtusa alba, ad 2·6 cm. longa, ad 1·75 mm. lata; staminodia alba, interdum stamina excedentia; filamenta ca. ad 8-seriata, ad 8 mm. longa, antheris pollineque primum luteis; ovarii lobi discum non attingentes, per 1 mm. elevati; stigmata gracillima, ad 8 mm. longa cum cauda 1 mm. longa.

Cape Province: Namaqualand; Swartpoort, Richtersveld, "about 3 miles upstream from Sendelings Drift," *H. Hall* 1308a, N.B.G. 107/58a. Fl. Mart.—Apr. 1961.

Astridia citrina L. Bol. sp. nov.—*A. rubra* (L. Bol.) L. Bol. var. *citrina* L. Bol., in vol. XXVII: 170 (Jul. 1961)—Rami 3 visi, 8—18 cm. longi, ad 8 mm. diam., internodiis ad 2·5 cm. longis; ramuli ultimi 2-foliati; partes herbaceae in siccis fere albae asperaeque; folia saepius fere erecta, matura subfalcata, supra plana linearia, prope apicem leviter angustata, acuta vel obtusa, lateribus convexulis, obtuse carinata, lateraliter visa prope apicem leviter angustata, obtusa vel subacuta, ad 7 cm. longa, 8—10 mm. lata, ad 1·9 cm. diam., eis bracteas subtendentibus praecipue magnis, ad 5 cm. longis; bracteae manu complanatae in circuitu ovatae, e supra medium angustatae, obtusae, rubre marginatae, 1·1 cm. longae, medio 1 cm. lato; receptaculum globose obconicum, 6 mm. longum, apice 10 mm. diam.; sepala e basi angustata, obtusa vel subacuta, interiora interdum obtuse breviterque subulata, 8—11 mm. longa, basi 5—8 mm. lata; petala ca. 3-seriata, sat laxa, interiora pauca, e supra medium inferne angustata, obtusa vel emarginata, cum staminodiis, filamentis stigmatibusque, citrina, 1—2·4 cm. longa, 1—3 mm. lata; staminodia inferne ciliata, stamina subaequantia; filamenta ca. 7-seriata, antheris pollineque luteis; ovarii lobi acute compressi, discum non attingentes, ad 2 mm. elevati; stigmata gracillima, ad 1·1 cm. longa cum cauda ad 2 mm. longa; capsula unica senecta imperfectaque tantum visa, valvis 2 ample alatis, alis e parum supra basim liberis; semina muricata brunnea.

South-West Africa; in the southern parts, *E. Rusch* et *F. Erni*. Fl. Government Gardens, Windhoek, Jul.—Aug. 1937, numerata 58. Comm. *H. M. Holloway*.

These notes are made partly from the living, and partly from the dried, material as well as from Miss B. O. Carter's drawings made from life. In her drawing of the expanded capsule the semi-obovate wings are shown attached to the valve for their whole length. This is the first species of *Astridia* to be recorded with winged valves.

Conophytum middlemostii L. Bol. sp. nov. *(Euconophytum-Wettsteiniana)*.—

Corpuscula obconica, supra plana, 1 cm. longa, 9 mm. lata, 1 cm. diam., ore 3 mm. longo; vaginae persistentes cum aetate dense crebrae, superiores inferne pergamentaceae, pallide brunneae, politae, superne interdum sat dense rubre brunneo punctatae, ad 1·2 cm. longae; pedunculi ad 3·5 mm. longi, apud basim bracteati, bracteae primum carnosissimae, lateraliter visae obtusae, 3 mm. longae, vagina ad 2 mm. longa, apice in siccis rubre glandulifero, sinu lato; receptaculum ad 1·25 mm. longum, ad 2 mm. diam.; calyx ad 9 mm. longus, tubo membranaceo, 7 mm. longo, segmentis 5, obtusis; corolla 2·1—3·2 cm. longa, tubo pallido, 1·3—2·3 cm. longo, segmentis ca. 3-seriatis, obtusis vel subacutis, roseis, 0·5—1·25 mm. latis; stamina ca. 6-seriata, e parum infra medium tubi adnata, seriebus superioribus 2 breviter exsertis, antheris pollineque luteis; discus inconspicuus; ovarium conice elevatum, in stylum, 9—15 mm. longum, insensim transeuns; stigmata 5, ad 4 mm. longa.

Cape Province: Namaqualand; Richtersveld, Rooiberg, Jan. 1961, *A. J. Middlemost*. N.B.G. 410/61a. Fl. Apr. 1964.

Conophytum kennedyi L. Bol. sp. nov. (*Celatistamina-Fenestrata*).—Plantae plures floriferae visae, glabrae, ca. ad 2·5 cm. altae, ad 6 cm. diam.; vaginae persistentes crebrae, inferne tenuiter pergamentaceae brunneae, superne incrassatae griseaeque, ad 1·7 cm. longae; corpuscula oblonga vel late obovata, viridia, fenestra sat crebre saturate viride punctata, vel rarissime "insulis" paucis ornata, 1·3—1·9 cm. longa, 7—12 mm. lata, ad 1·5 cm. diam., ore 1·5—1·2 mm. longo; pedunculi ad 7 mm. longi, prope basim bracteati, bracteis ca. 1·5 mm. longis, lobis subobtusis, vagina parum longioribus; receptaculum ad 1·5 mm. longum, ad 2 mm. diam.; calyx membranaceus fugax, ca. 1 cm. longus, segmentis 5, ca. 1·5 mm. longis; corolla 1·8—2·2 cm. longa, tubo 1·2—1·5 cm. longo, aurantiaco, segmentis exterioribus ca. 3-seriatis, apice rotundo vel subtruncato emarginatoque, superne roseis, inferne albis itaque "oculum" album formantibus, 7—9 mm. longis, fere ad 2 mm. latis; staminodia sat pauca, omnino alba vel prope apicem rosea, obtusa vel acuta, ca. ad 4 mm. longa; stamina 4—7-seriata, e parum infra medium tubi adnata, suprema apicem tubi attingentia; discus sat humilis, segmentis truncatis; ovarium supra circa marginem concavum, medio conice elevato, altitudinem disci fere attingente; stylus ca. 1·75 mm. longus; stigmata 5, ad 2·5 mm. longa; capsula infra globose obconica, fere 2 mm. longa, ad 4 mm., expansa 9 mm., vel cum appendicibus 11·5 mm., diam., supra circa marginem plana, medio per 1·5 mm. acute elevato, alis valvarum semicircularibus, omnino adnatis, apicem attingentibus, valvis ultra alas appendiculatis, appendice 1·25 mm. longa.

Cape Province: Namaqualand; "on the farm Smôrenskadu, 25 miles E. of Springbok on the road to Pofadder", Jul. 1962, *H. C. Kennedy*. N.B.G. 655/62. Ibidem, Jul. 1965, *H. Hall* 2993. (Typus). Fl. Apr. 1966. N.B.G. 302/65.

This species is closely allied to **C. lithopoides** L. Bol., the type of which also has the valves of the capsule appendiculate, as was portrayed by Miss B. O. Carter in her drawing, but by an oversight on my part was not included in the type-description. It differs from that species in having the vegetative parts glabrous (not "very minutely setiferously papillate"), the persistent sheaths thicker, the window without a coloured dendritic marking, the peduncle longer and the bracts much shorter.

The appendix of the valves of the capsule appears to be the persistent remains of the style and requires further investigation by the botanists who make a special study of the capsules of the *Mesembrieae*.

Lampranthus antonii L. Bol. sp. nov.—Plantae ferae 3 visae, glabrae. **Cephalophyllum** sat simulantes, caespitosae, ca. ad 4 cm. altae, ramos reptantes, 5—12 cm. longos, internodiis 2·5—3·5 cm. longis, emittentes; folia ascendentia vel fere erecta, supra visa linearia, e supra medium leviter angustata, acuta apiculata, lateribus convexulis, dorso rotundo vel carina ad lineam reducta, 2—5 cm. longa, medio 2—6 mm. lata, 2—5 mm. diam.; flores solitarii, 5—6·6 cm. diam.; pedunculus 7—13 mm. longus; receptaculum subclavatum, 5—7 mm. longum, 6—7 mm. diam.; sepala 5, subaequilonga, ad 8 mm. longa, basi 5 mm. lata, exteriora 2 acuta, interiora latissime brunneo marginata; petala ca. 4-seriata, intima pauca filamentosa, inferne leviter angustata, obtusa alba, cum aetate pallidissime rosea, 1·5—2·7 cm. longa, 1·5—2 mm. lata; staminodia nulla; stamina ca. 4—5-seriata, filamentis epapillatis albis, ad 5 mm. longis, antheris pollineque primum luteis; discus crenulatus; ovarium supra profunde concavum, lobis inconspicuis; stigmata 5, anguste subulata, caudata, 5—6 mm. longa cum cauda ad 2 mm. longa; capsula inferne globose obconica, 10-costata, ca. ad 1·1 cm. longa, ad 9 mm., expansa 14 mm., diam., supra per 3 mm. elevata, suturis leviter compressis, carinis cucullatis, inferne divergentibus, superne convergentibus, apicem valvae attingentibus.

CAPE PROVINCE: in dit. Ceres; "N. of Ceres at W. foot of Agterwitzenberg Pass, common on moist rocks." Sept. 1965, *Antony V. Hall* 1053.

Lampranthus gracilipes (L. Bol.) N.E.Br. forma **luxurians**.—Flores meridiani, ad 3·9 cm. diam., diutini, sepalis autem recurvatis manentibus; petala e medio vel supra inferne angustata, apice rotundo, nitente parpureo rosea, externe pallidiora, ad 1·7 cm. longa, ad 2·5 mm. lata; staminodia nulla; filamenta 3—4-seriata, ad 2·5 mm. longa, intima prope basim roseo papillata; ovarium circa marginem planum, deinde leviter elevatum, lobis fere erectis, distantibus; stigmata inferne anguste subulata, ad 2·5 mm. longa cum cauda 1 mm. longa; capsula infra subglobosa, ca. 6 mm. longa, 5 mm., expansa 1 cm., diam., carinis inferne parallelis, superne patentibus, marginibus laceratis cum alis apicem valvae attingentibus.

Cape Province: in dit. Clanwilliam; Pakhuis Pass, Oct. 1965, *H. Hall* 3039.

The type of this species was obtained in 1924 from the Piquetberg exhibit at a wild-flower show in Cape Town, the exact locality and collector being unknown. It was published in 1929 (Mesemb. II: 73). The first collection of documented specimens was made by H. Bolus in 1892 near Piquetberg, followed by two of N. S. Pillans in 1934 and 1935. From 1930 onwards the range of distribution recorded extended to Grey's Pass, then in the Clanwilliam Division from Witte Els Kloof, Krakadouw Poort, Uitkyk Pass, Pakhuis, and finally a collection made by E. Esterhuysen in the Vanrhynsdorp Div. on the Giftberg Plateau in 1958. All these collections are represented in the Bolus Herbarium.

Key to the Species of Astridia.

1. Herbaceous parts glabrous	
2. Upper surface of leaves lanceolate acute; staminodes absent	VANHEERDEI
2. Upper surface of leaves linear; staminodes present	
3. Upper surface of leaves round at the apex	HERREI
3. Upper surface of leaves acute or acuminate	
4. Outer petals dense, red, up to 2·2 cm. long, 2 mm. broad	LONGIFOLIA
4. Outer petals lax, bright purplish red, up to 3 cm. long, 3 mm. broad	VANBREDAI
1. Herbaceous parts ± velvety	
5. Petals white or pale lemon	
6. Staminodes present	
7. Petals white, stigmas as long as, or shorter than, the stamens	
8. Upper surface of mature leaves ovate acuminate or lanceolate, apex erect	DINTERI
8. Upper surface of mature leaves linear-lanceolate, apex recurved	ALBA
7. Petals pale lemon; stigmas well exceeding the stamens	CITRINA
6. Staminodes absent	
9. Leaves strongly compressed laterally, acutely keeled, up to 8 cm., or cultivated 11·7 cm., long; filaments white	HALLII
9. Leaves not compressed, obtusely keeled, sides convex, up to 6 cm. long; filaments yellow upwards	RUSCHII
5. Petals some shade of red or pink or salmon-pink, usually paler in the lower part	
10. Petals red	
11. All the sepals ± margined, the outer as broad as, or broader than, long	LATISEPALA
11. Outer sepals not margined, usually longer than broad	
12. Lobes of the ovary stellately spreading and reaching the disk	RUBRA
12. Lobes of the ovary ± erect, not reaching the disk	
13. Petals 6-seriate, red-orange; stigmas well exceeding the stamens	SPECIOSA
13. Petals 2—3-seriate, red; stigmas shorter than the stamens	SWARTPOORTENSIS
10. Petals pink or salmon-pink	
14. Petals pink; stigmas shortly caudate, leaves often falcate	
15. Upper surface of leaves oblong, usually obtuse or round at the apex	BLANDA
15. Upper surface of leaves linear or narrowly ovate, acute	DULCIS
14. Petals salmon-pink; stigmas long-caudate; leaves not falcate	HILLII

CORRECTIONS

Line 1, p. 201 for *Jensenobotrya vanheerdei*, L. Bol. read **Stoeberia carpiana** Friedr.

(I am indebted to Mr. H. Hall for drawing attention to this deplorable error.)

Mr. van Heerde's collection is the second one recorded for this species and it has extended the southern limit considerably.

KEY TO THE GROUPS AND SUBGROUPS OF **Trichodiadema** (AMENDED).

1. Papillae tipped with a soft hair—e.g. *T. strumosum, T. fergusoniae* . . STRUMOSA
1. Papillae not as above . . . . ESTRUMOSA
2. Leaves ± conspicuously tipped with bristles . . . . . . SETIFERA
3. Bristles radiating to form a diadem . . . . RADIANTIA
4. Plants low growing, densely compact or loosely branched —e.g. *T. densum, T. barbatum* . . . . BARBATA
4. Plants with elongated virgate branches—e.g. *T. setuliferum, T. pomeridianum* . . . . VIRGATA
3. Bristles erect, forming a tuft—*e.g. T. intonsum* . . . . STRICTA
2. Leaves not, or very obscurely, tipped with bristles—*e.g. T. attonsum* . . . . ATTONSA

NOTE.—The type specimens of all new species described in this paper are in the Bolus Herbarium, University of Cape Town.

(*To be continued*)

A NEW SPECIES OF CONOPHYTUM

R. C. Littlewood

(*National Botanic Gardens of South Africa, Karoo Garden, Worcester.*)

Conophytum lilianum Littlew. sp. nov. (*Celatistamina—Fenestrata*).—Plantae glabrae, caespitosae, e corpusculis 4—9 compositae; vaginae persistentes crebrae papyraceae brunneae; corpuscula biloba, cordata, inferne translucente punctata, viridia, 9—11 mm. longa, 3—4 mm. lata, 6—8 mm. diam. cum divergio 0·5—3 mm. longo, lobis apud apicem ovalibus vel fere rotundis; fenestra convexula, subrubra vel purpureo brunnea, saturate viride punctata, punctis translucentibus et confluentibus; receptaculum inclusum; calyx partim inclusus, membranaceus, 6 mm. longus, segmentis 4, aurantiace brunneis, 1 mm. longis; corollae tubus aurantiace brunneus, 11—12 mm. longus, segmentis 2-seriatis obtusis albis, apicem versus saturate roseis, cum aetate pallidioribus, 7 mm. longis, 1·5 mm. latis; staminodia 1-seriata, linearia aurantiaca, 3 mm. longa, 0·5 mm. lata; stamina 4-seriata; ovarium supra conice elevatum; stylus viridis, 1 mm. longus; stigmata 4, lutea, 0·5 mm. longa.

Cape Province: Namaqualand; 4 miles South of Garies, in shallow granite-rock pans, with a western aspect, June 1965. *R. C. Littlewood.* Karoo Garden 168/65 (typus). Fl. April 1966. Also collected in the same locality Sept. 1959. Karoo Garden 700/59.

24 specimens of K. G. 168/65 have been examined.

This species is named in honour of my wife, Lilian, in grateful recognition of the encouragement and the valuable practical assistance she has given me in the many highly satisfactory collecting expeditions I have made on behalf of the Karoo Garden from 1959—1965.

Acknowledgement

My sincere thanks are due to Dr. L. Bolus for her invaluable guidance and assistance.

NOTES ON *ERICA VIRIDIFLORA* AND THE DESCRIPTION OF A NEW ERICA SPECIES

H. A. Baker

Erica viridiflora Andr. Heathery, t. 229.

The corolla in this species is described correctly by Andrews as viscid and collections made recently confirm this; the leaves too are viscidulous. In Flora Capensis the corolla is described as dry. Moreover the species has been placed in section 2, Didymanthera, in which the corollae are stated to be dry. Owing to this and other discrepancies and omissions in the Fl. Cap. description found on examining fresh material from its natural habitat it is thought desirable to publish a new description. As it stands now it is very misleading. *E.viridiflora* is probably best retained in this section on account of the anthers being sublateral and would be an exception in any other section. It will be necessary, however, to add after the word "dry", "or, rarely, viscid".

DESCRIPTION

Erect, much branched, to 90 cm. or so. *Branches* pubescent, glabrescent. *Leaves* 3-nate, closely set, spreading, oval, obtuse, sulcate, thick, viscidulous, the younger ciliate, 3—8 mm. long. *Flowers* terminal 3-nate, cernuous; peduncles densely pubigerous, 3—5 mm. long; bracts closely imbricating the calyx, broad-ovate to orbicular, concave, strongly keel-tipped, scarious, glabrous, ciliate, green with, often, reddish-brown patches of variable size which are very conspicuous in the flowering plant, 4 mm. long. *Sepals* closely clasping the corolla, very imbricate, the outer usually longer than the inner, ovate, keel-tipped and more or less keeled, otherwise like the bracts, 8—10 mm. long. *Corolla* tubular, somewhat restricted below by the calyx, glabrous, very viscid, green and, unlike the bracts and sepals, turning brown all over after maturity, 2·8 cm. long; lobes slightly speading, oblong, obtuse, 5 mm. long. *Filaments* 0·4 mm. wide, broadening above at the darker-coloured connective; anthers manifest to exserted, sublateral, oblong, bipartite and divaricate, dark-coloured, appendiculate, 4 mm. long; pore about $\frac{3}{4}$ the length of the cell; awns broad at the base then turning sharply downwards and narrowing to a sharp out-curved point, about 1 mm. long, more rarely absent. *Ovary* oval, glabrous; style exserted; stigma simple.

DISTRIBUTION

Cape Province: Mountains in the Mossel Bay and George Divisions.

Flowering season. Winter, but probably at most other times. This description was made from a collection in Robinson Pass 2,300 ft., *Baker* 2471, in Bolus Herbarium, July 1965. The plants were numerous and mixed up with *E.unicolor* which is also green and viscid with tubular flowers but resemblance ends there. The two species are very different in structure, particularly in the shape and set of the leaves, which feature alone marks the two as different species when seen growing together.

Erica coacervata H. A. Baker sp. nov. (*Ericaceae-Ericoideae*) Ceramia.

DESCRIPTION

Frutex depressus, densus, valde ramosus, inter saxa reptans. *Rami* pubigeri pilis brevibus in longitudine variabilibus et pilis longioribus glandulosis mixtis. *Folia* 3-nata plus minusve diversa et recurva, ovata ad oblonga, obtusa, crassa, carinata, sulcata, supra pubescentia et ex pare bracteis et sepalis breviter ciliata et pilis longis setaceis glandulosis admixtis, petiolis inclusis fere 4 mm. longa. *Flores* in umbellis 1—6 natis terminalibus, coacervates ramis in longitudine valde variabilibus interdum in parte superiore sine folius; pedunculi pilosi ramis similes, fere 6 mm. longi; bracteae 2·2 mm. longae; approximatae, inferior foliacea sed superne glabra, pilis ciliatis glandulosis, quam alibi valde longioribus pare superiore anguste elliptico et longiore. *Sepala* 2 mm. longa, ovato-lanceolata, apice sulcata, brevissime puberula ad glabra. *Corolla* urceolata, in faucibus vix constricta, leviter puberula, venosa, arida, obscure purpureo-rubicunda vel rubicunda, 7 mm. longa; lobis leviter extendentibus, obtusis et margine crenulatis, 1 mm. longis. *Antherae* inclusae vel tantum manifestae, laterales, oblongae ad angusto-ellipticae, alte bilobatae, leves, appendiculatae, 1·2 mm. longae; poro fere quarta pars lobi; cristae infra latae et subulatae, rectae, 0·5 mm. longae. *Ovarium* turbinatum, villosum; stylo exserto; stigmate capitato.

DISTRIBUTION

Cape Province, Worcester Div.: Summit of Waaihoek Peak, 6,400′, sprawling amongst and over rocks, *Esterhuysen* 22613, 12/1/54, (Holotype in Bolus Herbarium); Pic Delville, 5,800′, *Esterhuysen* 28740; Fonteinjesberg, 6,000′, *Esterhuysen* 8780, and on the same plateau young sprawling plants after a fire, *Esterhuysen* 20,000; Mostert's Hoek Twins S. side, low matted shrubs, 6,600′, *Esterhuysen* 9846; Sentinel Peak, Hex River Mts., *Esterhuysen* 8408; Milner Peak, steep ledges at head of kloof between Milner Peak and Milner Needle, 6,500′. *Esterhuysen* 28101; Keeromsberg, 6,000′, *Heatlie* 27645; Ceres Div.: Roodeberg, Matroosberg group, in damp conditions on ledges at the base of the

shale band, 5,500′, *Heatlie* 27696; and collected by G. T. Jackson on Keeromsberg (*Marloth* 3891); near the top of Roodeberg, 6,500′, *Stokoe* 7833.

Flowering season. Summer.

A much branched, low, dense shrub sprawling amongst and over rocks. *Branches* pubigerous with shortish hairs of different lengths and with longer, setaceous, gland-tipped hairs intermixed. *Leaves* 3-nate, spreading to wide-spreading and recurved, ovate to oblong, obtuse, thick, keeled, sulcate, pubescent above and, like the bracts and sepals, shortly ciliate and with long, setaceous gland-tipped hairs intermixed, about 4 mm. long including the 1 mm. long petiole. *Flowers* clustered in umbels of 1—6 flowers at the ends of branchlets of very variable length which, in some cases, are leafless in the upper portion; peduncles hairy like the branches, about 6 mm. long; bracts approximate, 2·2 mm. long, the lowest one foliaceous but glabrous above and with setose, gland-tipped, ciliate hairs much longer than in the other parts; the upper pair narrow-elliptic and longer. *Sepals* ovate-lanceolate, sulcate at the apex, very shortly puberulous to glabrous, 2·5 mm. long. *Corolla* urceolate, scarcely narrowed at the throat, sparsely puberulous, veined, dry, dull purple-pink, pink or red, 7 mm. long; lobes slightly spreading, obtuse and crenulate on the margins, 1 mm. long. *Anthers* included to manifest, lateral, oblong to narrow-elliptic, deeply bilobed, smooth, appendiculate, 1·2 mm. long; pore about

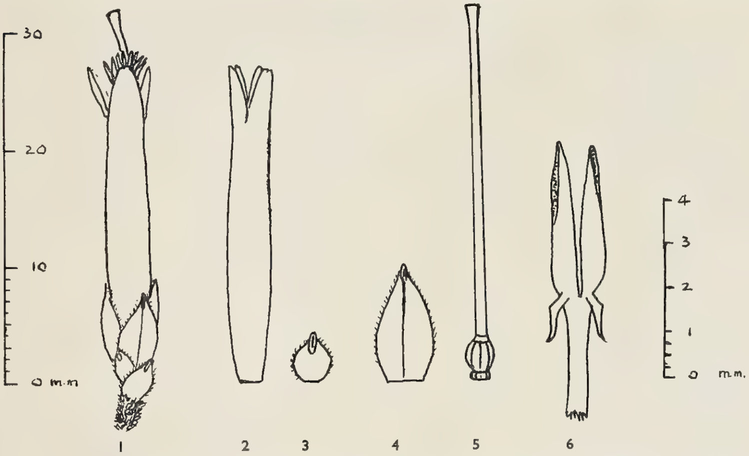


FIG. 1. *Erica viridiflora.* Andr. from *Baker* 2471. 1. Flower; 2. Corolla; 3. Bract; 4. Sepal; 5. Gynoecium; 6. Anther, back view much enlarged.

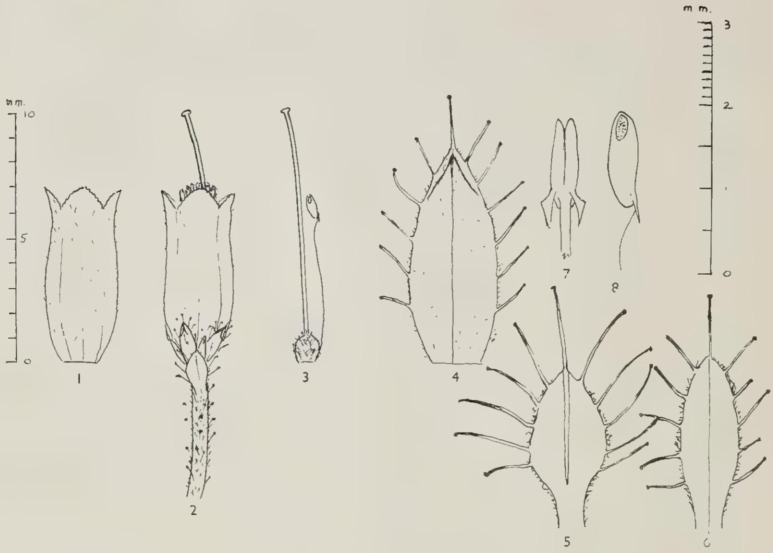


FIG. 2. *Erica coacervata*. 1. Corolla; 2. Flower; 3. Gynoecium; 4. Sepal; 5. Lower Bract; 6. Upper Bract; 7. Anther back; 8. Anther side.

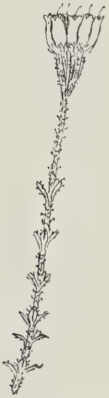


Fig. 3. *E. coacervata*
Sprig, natural size.

$\frac{3}{4}$ the length of the cell; crests wide at the base and subulate, straight, 0·5 mm. long. *Ovary* turbinate, villous; style exserted; stigma capitate.

E. coacervata has been placed in the section Ceramia on account of its sprawling habit although the corolla is unusually long for this section. It is a very distinct species and cannot be said to be closely related to any other yet discovered. It is chiefly interesting on account of the diversity of the hairs on all parts and particularly the very long gland-tipped setose ciliations on the bracts and the shorter ones on the sepals, forming an impenetrable obstacle round the ovary.

The author is indebted to Captain T. M. Salter for the Latin translation, to the Curator of the Bolus Herbarium for the use of facilities there and to Miss E. Esterhuysen for allowing him to use this material.

OBSERVATIONS ON THE TEMPERATE AFFINITIES OF THE VEGETATION OF HANGKLIP MOUNTAIN NEAR QUEENSTOWN, C.P.

B. R. Roberts

(*Department of Pasture Science, University of the Orange Free State*)

Abstract

The vegetation of Hangklip mountain (6848′) is described on the basis of the main communities delineated on the physiognomy and affinities of the dominants concerned. The floristic composition of nine communities is described, the following communities being recognized: Mixed Thornveld of the plains, Mixed Ravine Bush of the lower xerocline, *Elyonurus* grassveld of the mid-altitude plateaux, *Leucosidea* Open Woodland of the southern slopes, *Bromus-Chrysocoma* association of the upper southern slopes, *Festuca scabra* consociation of the upper mesocline, *Buddleia* forest of the high altitude ravines, Rock Scree communities and *Harpechloa-Danthonia-Pentaschistis* grassveld of the summit plateau.

The temperate affinities of the communities are discussed in relation to altitude and aspect influences. The significance of the temperate flora is explained in the light of the relevant literature.

INTRODUCTION

Hangklip mountain is a striking landmark several miles north of Queenstown in the eastern Cape Province, situated at latitude 31° 53′ S and longtitude 26° 53′ E. The mountain rises to a height of 6848 feet above sea level and is constituted for the most part of sedimentary geological formations of the Beaufort Series, with the exception of the perpendicular-sided summit formed by a massive dolerite buttress which dominates the scenery for many miles around (Plates 1—3).

The climate of the area is characterized by an erratic summer rainfall which averages 21″ (533 mm.) per annum, of which only 7% falls during the months of June, July and August. Temperatures for the period 1873–1950 as measured at Queenstown are given in Table 1.

Table 1

Average monthly temperatures for Queenstown 1873—1950 *in degrees centigrade*

J	F	M	A	M	J	J	A	S	O	N	D	Mean
22·1	21·9	20·5	17·1	13·6	10·7	10·3	12·6	15·3	17·5	19·1	21·3	16·9

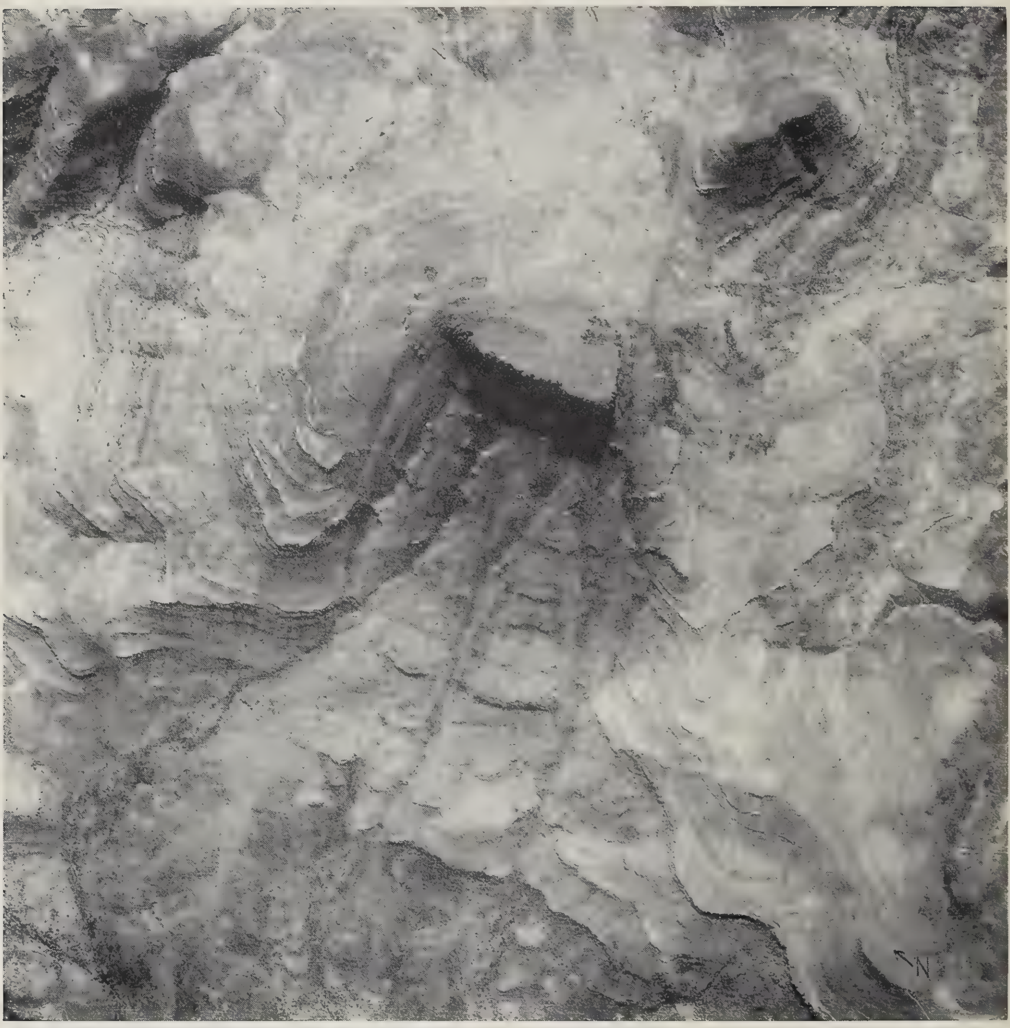


PLATE 1
Aerial photograph of Hangklip Mountain (1;10,000).
Photo: Director, Trigsurvey, Pretoria

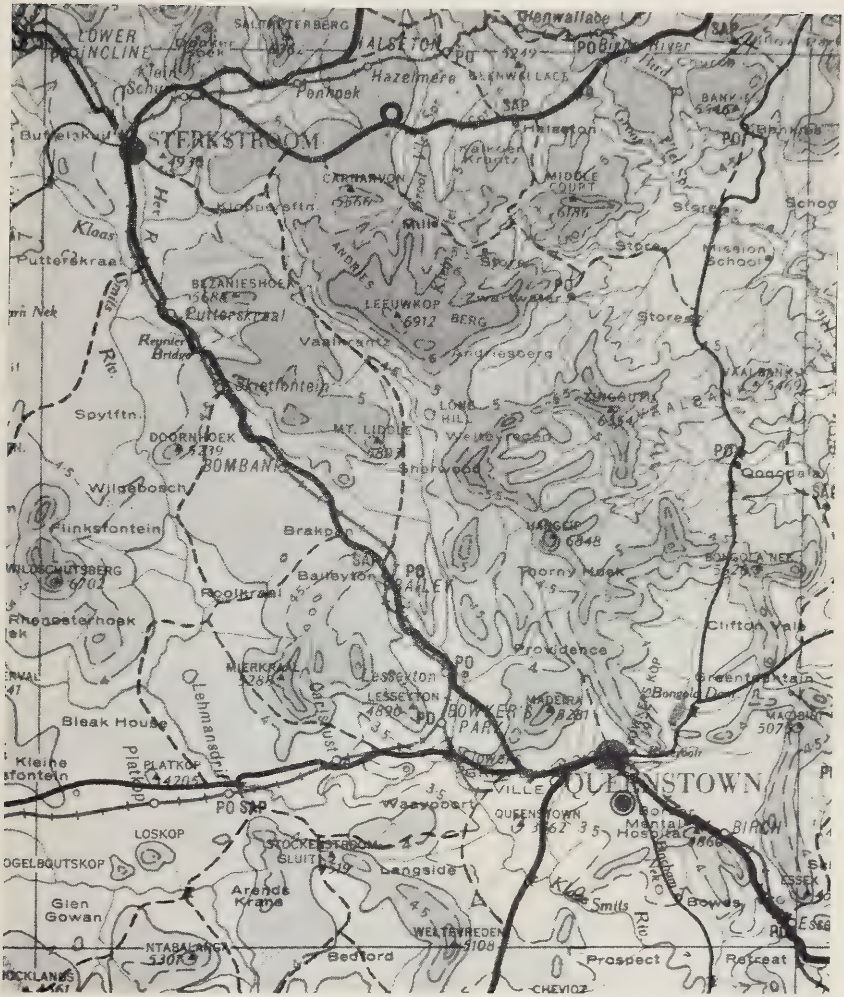


Plate 2
Map of Queenstown and Environs

The average lowest minimum and highest maximum temperatures recorded over the above-mentioned period are –3·9°C (July) and 38·0°C (January).

The surrounding country, which lies between 3500′ and 4000′ consists of gently undulating grassveld, with varying degrees of *Acacia* thicket formation occurring in the lower-lying regions. The vegetation of the plains in this area is made up almost entirely of species belonging to the subtropical element of the South African flora and of particular interest to the ecologist is the manner in which genera of the temperate element become more important with increase in altitude on Hangklip mountain. This change in both physiognomy and floristic composition can only be ascribed to micro-climatic changes with altitude since geological formations and edaphic features on the upper portion of the mountain closely resemble those at lower altitudes where the normal sweetveld savannah occurs.

PLATE 3
Hangklip from the south

The Vegetation

The vegetation has been classified into nine main communities on the basis of physiognomic dominants and affinities of the vegetation. Since this study is aimed only at recording the presence and importance of species with subtropical and temperate affinities, no consideration is given to quantitative measures. The communities recognised are:

1. Mixed Thornveld of the plains.
2. Mixed Ravine Bush of the lower xerocline.
3. *Elyonurus* grassveld of the mid-altitude plateaux.
4. *Leucosidea* Open Woodland of the southern slopes.
5. *Bromus-Chrysocoma* association of the upper southern slope.
6. *Festuca scabra* consociation of the upper mesocline.
7. *Buddleia* forest of the high altitude ravines.
8. Rock Scree communities.
9. *Harpechloa-Danthonia-Pentaschistis* grassveld of the summit plateau.

Specimens of all the plants listed in this paper are preserved in the herbarium of the Department of Pasture Science, University of the Orange Free State, Bloemfontein and a duplicate set has been sent to the National Herbarium, Pretoria. Numbers are the writers' collectors' numbers.

1. *Mixed Thornveld community of the plains* (Plate 4)

The *Acacia* savannah of the plains varies greatly in botanical composition and at the base of the mountain on the northern side the following species are the most important:

Acacia karoo Hayne.
Euclea crispa var. crispa (Thunb.) Guerke var. crispa de Winter.
Scolopia mundii (E. & Z.) Warb.
Diospyros whyteana (Hiern) F. White.
Trimeria trinervis Harv.
Clematis brachiata Thunb.
Asparagus iocladus (sp. compact).
Maytenus cymosus.
Melolobium calycinum Benth.
Aster filifolius Vent.
Aster muricatus Less.
Chrysocoma tenuifolia Berg.
The grass cover is made up largely of sweetveld species and includes:
Themeda triandra Forsk.
Elyonurus argenteus Nees.
Heteropogon contortus (L.) Beauv.
Cymbopogon plurinodis. Stapf ex Burtt Davy.
Melica racemosa Thunb.
Eragrostis curvula (Schrad.) Nees.
E. lehmanniana Nees.
E. obtusa Munro ex Fic. et Hiern.
E. chloramelas Steud.
Aristida congesta Roem. et Schult.
A. curvata Nees Trin. et Rupr.
Sporobolus fimbriatus Nees.

Overgrazing has resulted in severe erosion in this low-lying area. The purple shale formation on which this community occurs is particularly susceptible to surface erosion and wherever this shale occurs on a slope and denudation of the grass sward takes place, sheet- and later gulley-erosion soon follow. Injudicious chopping of thornbush, presumably for firewood, has led to replacement of the original open *Acacia* savannah by a dense thornbush thicket in some areas.

2. *Mixed Ravine Bush of the lower xerocline*

The vegetation on the xerocline follows the pattern so often found on mountains in the semi-arid areas of South Africa, namely dominantly grassveld except in ravines and rocky areas where woody plants tend to dominate, largely as a result of the improved moisture conditions and protection in such habitats. In the case of Hangklip, the xerocline ravine bush community is a mixture of the shrubs of the plains and the more mesophytic trees typical of the upper mesocline forest. Thus in addition to the woody plants listed above under the Thornveld community of the plains, the following woody species are also common constituents of the mixed ravine bush of the xerocline:

Halleria lucida L.
Cussonia paniculata E. & Z.
Rhus glauca Desf.
Rhus erosa Thunb.
Grewia occidentalis L.
Myrsine africana L.
Olea africana Mill.
Scolopia zeyheri (Nees) Harv.
Pavetta capensis (Houtt.) Brem.
Clutea pulchella L.
Rhamnus prinoides L. Herit.
Encephalartos cycadifolius Lehm.

Typical of warm dry rocky sites such as occur along the margins of the xerocline ravine bush is the grass *Setaria lindenbergiana* (Nees) Stapf which, according to the writer's observations in neighbouring districts (Roberts, 1963) is largely limited to such habitats in this region.

PLATE 4
Mixed bush on lower N. slope of Hangklip

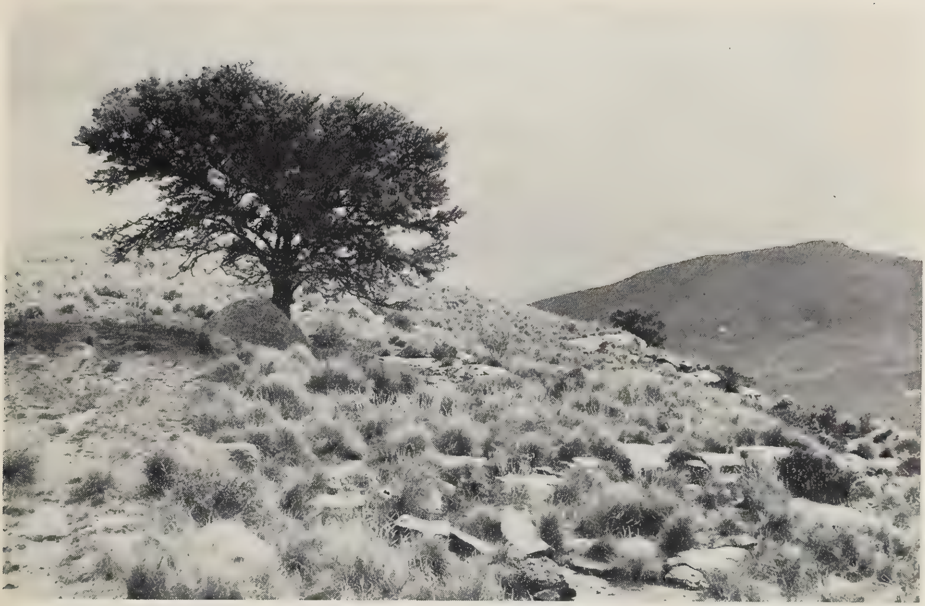


Plate 5
Elyonurus grassland on N. slope

3. **Elyonurus** *grassveld of the mid-altitude plateaux* (Plate 5)

The geological structure of the mountain, being constituted of strata of sedimentary rocks, has given rise to a number of mountainside plateaux of varying size on the northern and eastern aspects. These plateaux display a mixed grassveld, dominated by the "sour" species *Elyonurus argenteus* Nees which is clearly actively increasing as a result of selective grazing. This grassveld occurs between 5000′ and 6000′ immediately above the zone at which *Acacia karoo* and *Olea africana* disappear. The grass cover of this community contains all the species listed in the *Acacia* thornveld together with a high proportion of sourveld species such as *Eragrostis capensis* (Thunb.) Trin., *E. racemosa* (Thunb.) Steud. and *Tristachya hispida* (L. f.) K. Schum.

4. **Leucosidea** *Open Woodland of the southern slopes*

This is an open woodland consisting mainly of *Leucosidea sericea* E. & Z. trees in a short mixed grassveld and occurs on stoneless slopes adjacent to the

Festuca scabra grassveld at high altitudes on the southern slopes. Indications are that, in the absence of boulders, fire has eliminated all tree species, with the exception of *Leucosidea* which has been observed by the writer to form pure consocies in mountain sourveld which is subjected to periodic fires in many high rainfall areas, e.g. Basutoland, Golden Gate, Witsieshoek, Thaba 'Nchu, Zastron and Giants' Castle. Ecologically this woodland may be considered as being below the *Buddleia* forest in the succession, owing to the latter's mixed dominance, closed canopy and variety of species in a number of strata.

5. **Bromus-Chrysocoma** *Association of the upper southern slopes*

The upper southern slopes situated immediately below the main precipice, experience unique environmental conditions as compared with other habitats in the locality. The *Bromus-Chrysocoma* association described below occurs on a steep southern slope of sandy soil which is virtually black as a result of the marked accumulation of organic matter. This habitat receives a reduced amount of direct sunlight which strikes the soil surface at an oblique angle during the summer and no direct sunlight at all during the winter. Theoretically the physiographic features which make up this habitat (altitude, aspect, slope and the proximity the massive precipice above) should combine to produce the coolest and most moist habitat in the area under investigation. The influence of these microclimatic factors is directly reflected in the floristic composition of the community which occurs here. Scarcely a single grass species of tropical affinity is found in this community, while the following species are typical:

Bromus leptocladus Nees.
Danthonia purpurea (Thunb.) Beauv.
Danthonia districha Nees.
Danthonia stricta (Nees) Schrad.
Danthonia macowanii Stapf.
Lasiochloa longifolia (Schad.) Kunth.
Festuca scabra Vahl.
Festuca caprina Nees.
Ehrharta calycina Sm.
Ehrharta erecta Lam.
Pentaschistis setifolia (Thunb.) McClean.
Pentaschistis sp. (Roberts, 2038).
Helictotrichon longifolium (Nees) Schweickerdt.
Trachypogon spicatus (L. f.) O. Ktze.
Koeleria cristata (L.) Pers.
Cymbopogon proxilus (Stapf.) Phillips

All the woody plants which are associated with the above temperate grasses in this cool mesophytic habitat are of the sclerophyllous type and most of them may be regarded as relics of an earlier macchia vegetation, namely:

Cliffortia paucistaminea H. Weim.
Anthospermum tricostatum Sond.
Thesium imbricatum Thunb.
Passerina montana Thod.
Passerina sp. (Roberts 2001).
Erica schlecteri Bol.
Elytropappus rhinocerotis Less.
Relhania pungens L'Herit.

Together with these sclerophyllous bushes, *Chrysocoma tenuifolia* Berg. occurs very frequently, forming large consociations within this mixed temperate community. The abundance of *Chrysocoma* in this habitat is of particular ecological interest in view of the encroachment and domination of this bush over large areas of the eastern karoo and southern Orange Free State, where it appears equally well adapted to hot, dry plains.

Herbs of general occurrence in this community include:

Senecio juniperus L.
Senecio isatideus DC.
Senecio hieracioides DC.
Helichrysum capillaceum Less.
Helichrysum chionosphaerum DC.
Helichrysum trilineatum DC.
Helichrysum dregeanum Harv. & Sond.
Helichrysum subglomeratum Less.
Helichrysum miconeaefolium DC.
Myosotis sylvatica Hoffm.
Delosperma sp. (Roberts 2132).
Osteospermum caulescens Harv.
Scabiosa columbaria L.
Sutera? floribunda (Roberts 2029).
Chaetacanthus setiger (Pers) Lindau.
Berkheya purpurea (DC.) Mast.
Melolobium microphyllum E. & Z.
Ornithogalum leptophyllum Bak.
Trachyandra saltii (Bak.) Oberm.
Gladiolus permeabilis de la Roche.

A striking feature of the ground layer of this community is the great abundance of the prostrate clover *Trifolium burchellianum* Ser. which covers and binds the sloping sandy soil by forming extensive dense mats on the soil surface.

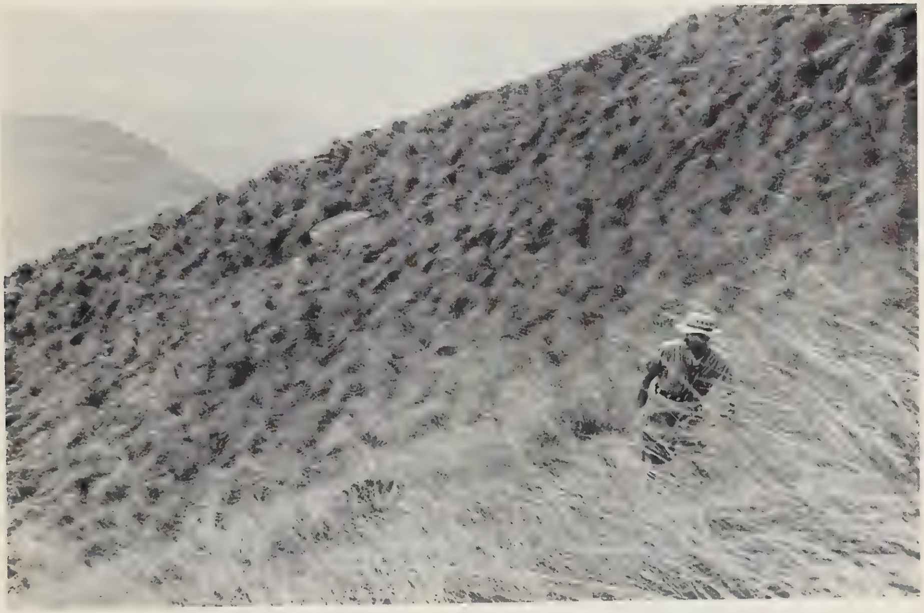


PLATE 6
Festuca Grassland on upper southern aspect

6. **Festuca scabra** *consociation of the upper mesocline* (Plate 6)

Those portions of the upper southern slopes which are devoid of boulders are completely dominated and covered by a dense uniform growth of virtually pure *Festuca scabra* Vahl. This grass is characteristic of cool high altitude sourveld in the nearby Amatole mountains, but nowhere has the writer encountered such a homogeneous mass of huge tufts of this grass as occurs on Hangklip. No explanation can be given for the exclusion of virtually all other species from this community. A closely related species, namely *Festuca costata* Nees occurs abundantly in the mountains of the nearby region known as the Bontebok Flats.

7. **Buddleia** *forest of the high altitude ravines* (Plate 7)

Four roughly parallel ravines run from below the imposing summit precipice to the foot on the south western aspect of the mountain. Beside the marked change in the species of woody plants with altitude within the ravines, soil conditions, varying from sandy to clayey doleritic soil and from deep soil to typical scree conditions with massive boulders, are associated with a marked variation in structure and floristic composition of the forest. The general pattern is a gradual change from bush dominated by *Acacia karoo* to a mixed ravine bush, at about 5000′, which is similar in composition and structure to the mixed bush of the xerocline ravines. This mixed bush then gives way to a more mesophytic bush between 6000′ and 6500′ and since *Buddleia salvifolia* Lam. is the dominant in large areas of the upper reaches of these ravines, the name *Buddleia* forest has been given to this advanced community. The following trees and shrubs are typical of this community:

Buddleia salvifolia Lam.
Kiggelaria africana L.
Clutea pulchella L.
Heteromorpha trifoliata (Wendl.)
Rhamnus prinoides L'Herit.
Halleria lucida L.
Rhus divaricata E. & Z.
Rhus glauca Desf.
Rhus dentata Thunb.
Euclea crispa var. crispa (Thunb.) Guerke.
Euclea coriacea A. DC.
Polemannia grossulariaefolia E. & Z.

Mention should here be made of the lichen *Usnea* locally known as "Spanish Moss" or "Old Man's Beard", which grows on the larger trees of this mesophytic forest. The presence of this lichen in such abundance gives some indication of the amount of atmospheric moisture prevailing on the southern slopes at higher altitudes.

The understory of this forest requires further investigation but contains amongst others the following species:

Asparagus microraphis Kunth.
Asparagus asparagoides (L.) Wight.
Clematis brachiata Thunb.
Geranium ornithopodum E. & Z.
Geranium harveyi Brig.
Linum thunbergii E. & Z.
Valeriana capensis Thunb.
Galium capense Thunb.
Galium rotundifolium L.
Anchusa capensis Thunb.
Silene burchellii Otth.
Silene capensis Otth.
Pelargonium leucophyllum Turcz.
Pelargonium sp. (Roberts 2091).
Nemesia capensis (Thunb.) Ktze.
Polygala serpentaria E. & Z.
Blechnum australe L.
Diascia stachyoides Schltr.
Melica decumbens Thunb.
Poa binnata Nees.
Ehrharta erecta Lam.
Cheilanthes multifida.
Woodsia burgessiana Genr.
Pellea quadripinnata (Forsk.) Prantl.
Polystichum lucidum (Burn.) Bech.

PLATE 7
Buddleia forest

Though limited in distribution and area, this closed forest must be regarded as the most well developed community within the area under investigation. The degree to which this community represents a climatic climax, is debatable, since although a *Podocarpus* climax is to be found in certain areas of the Amatole mountains in this district, the low temperature associated with altitudes above 6000′ may well preclude *Podocarpus* here as it apparently does on the nearby Hogsback range.

8. *Rock Scree Communities*

Difficulties arise in the delineation of the scree communities, however the following three groups have been recognized:

(*a*) **Aloe-Kiggelaria** *association of the upper northern screes.*

The rugged screes of huge lichen-clad dolerite boulders near the summit on the northern aspect provide a suitable habitat for those species requiring complete protection during the seedling stage, especially from fire. The two most important species growing in the deep crevices of these screes are *Aloe tenuior*? and *Kiggelaria africana* L. Constituents of this community in screes composed of smaller rocks, include most of the plants mentioned under the summit habitats. The wind-pruned appearance of both the aloes and the *Kiggelaria* trees indicates that high wind velocities play an important part in the determining the physiognomy of the vegetation in these sites.

(*b*) **Euryops** *consociation*

Amongst the fallen rocks on the talus slopes immediately below the eastern precipice of the summit buttress, the sclerophyllous shrub *Euryops brevipappus* M. D. Henderson ("Harpuisbos" or Paraffinbush) dominates the scree vegetation, forming large areas of bright-yellow flowered bush. Several other species of *Euryops* which are associated with incorrect veld management in the surrounding districts are encroaching on certain mountainous farms. *Euryops brevipappus* forms a dense almost inpenetrable thicket with the result that the ground layer of the vegetation is virtually absent beneath its canopy.

(*c*) **Relhania-Helichrysum** *association*

Of the various temperate communities on Hangklip mountain, the *Relhania pungens* L'Herit-*Helichrysum triclineatum* DC association is, from a physiognomic point of view, the most strikingly typical of the temperate flora. Even to the untrained eye this sclerophyllous scrub must appear foreign in an area with predominantly subtropical affinities in its vegetation. This scrub is very limited in size and distribution, the largest patch of it occurring in the upper north-western scree adjoining the summit plateau. Beside the two dominants mentioned above, other macchia representatives such as *Elytropappus rhinocerotis* and *Passerina montana* are constituents of this community.

9. **Harpechloa-Danthonia-Pentaschistis** *grassveld of the Summit Plateau* (Plate 8)

The summit plateau vegetation consists of a short dense grassveld, virtually devoid of all trees and shrubs. The soil is shallow and of doleritic origin. Soil depth varies according to local variations in slope and these variations have led to accompanying variations in plant cover. The occurrence of boulders is also associated with an invariable change in vegetation, presumably as a result of the protection which such stony habitats provide against the influences of wind and fire, which alone or in combination, are generally associated with the grassland formation.

Of the plants which constitute the exposed summit grassveld the following species are the most abundant:

Harpechloa falx (L.) O. Ktze.
Trachypogon spicatus (L. f.) O. Ktze.
Pentaschistis setifolia (Thunb.) McClean.
Pentaschistis sp. (Roberts 2038).
Koeleria cristata (L.) Pers.
Ehrharta calycina Sm.
Andropogon appendiculatus Nees.
Aristida junciformis ssp. galpinii Trin. et Rupr.
Danthonia purpurea (Thunb.) Beauv.
D. macowanii Stapf.
Microchloa caffra Nees.
Festuca caprina Nees.
Tristachya hispida (L. f.) K. Schum.
Eragrostis chloramelas Steud.
E. racemosa (Thunb.) Steud.
E. capensis (Thunb.) Trin.

Of the non-grasses only a limited number of stunted bushes and seasonal aspect *Monocotoledonae* occur to any marked extent under these exposed conditions, namely:

Helichrysum fulgidum Willd.
Cliffortia paucistaninea H. Weim.
Aster muricatus Less.
Eriospermum sp. (Roberts 2061).
Selago brevifolia Rolfe.
Clutea laxa Eckl.
Senecio asperulus D.C.
Cyrtanthus o'brienii Bak.
Bulbine abyssinica A. Rich.

Where large blocks of dolerite afford a more favourable habit, particularly situations sheltered from high winds, an unusual assortment of species is found, having affinities with many different communities, namely:

Euryops brevipappus M.D. Henderson.
Rhoicissus microphylla (Turcz.) Gilg & Brandt.
Kiggelaria africana L.
Clutea pulchella L.
Galium rotundifolium L.
Anachusa capensis Thunb.
Berkheya buphthalmoides (D.C.) Schltr.
Silene burchellii Otth.
Geranium ornithopodum E. & Z.
Schoenoxiphium sp. (Roberts 2057).
Cheilanthes sp. (Roberts 2058).
The exceptionally rare fern Woodsia burgessiana (Roberts 2055) also occurs in this mixed community.

The significance of the temperate vegetation of Hangklip

From a phytogeographic point of view the importance of the occurrence of

PLATE 8
Hangklip summit looking North

elements of temperate vegetation on Hangklip mountain is out of proportion to the size of these communities and their contribution to the vegetation as a whole. Since the theories surrounding the origin, migration and adaptation of the temperate ("Fynbos", Macchia or Cape) flora has a direct bearing on the understanding of the dynamic aspects of the other vegetation types present, the significance of the representatives of the temperate flora may be discussed in some detail.

The term "sclerophyllous bush" was originally employed by Schimper (1903) in describing the bush of winter rainfall areas of the world, including the south-western Cape. Warming (1909) used the word "maqui", for the Cape flora and at the present time the term "macchia" and its generally accepted Afrikaans equivalent "fynbos" are commonly used. All these terms refer to a community of evergreen shrubs with small ericoid or linear rolled leaves. The term "macchia" used in this text refers to growth form and not to any specific floristic composition.

A number of writers have discussed the origin of South African vegetation (Levyns, 1938; Marloth, 1929; Bews, 1925; Schonland, 1907 and 1909; Sim, 1920 and Bredenkamp, 1935) and it is generally agreed that macchia had a much wider distribution than is the case to-day (Rennie, 1935). In Acocks' (1953) words, "It was pushed back by the sward-forming tropical grasses, when they appeared, into its strongholds in the winter-rainfall areas and areas on mountain ranges and along coastlines where winter moisture is available and conditions are less suited to the tropical grasses. The picture is obscured by the surging backwards and forwards of vegetation types in response to less ancient changes of climate which we know to have more than once occurred. The relicts of Fynbos in tropical vegetation, therefore, may have more than one origin, though the presence of *Erica* in Europe and of *Podocarpus* and *Protea* in Central Africa is likely to be an indicator of the ancient distribution of Fynbos. It must here be pointed out that these climatic changes probably occurred over periods of tens of thousands, or hundreds of thousands of years, and not over periods of a century or less, like the changes in vegetation we are witnessing to-day".

The thickening up and movement of several species of the macchia vegetation in numerous parts of the summer-rainfall area indicate that the macchia migrations are still very active. Acocks (1953) regards the tall form of karoo vegetation which has invaded the inland mountains (Karroid *Danthonia* Mountain Veld and *Themeda-Festuca* Alpine Veld) as being so closely related to the macchia as to warrant its being regarded as macchia invasion. This movement includes *Cliffortia*, *Passerina* and *Pentzia cooperi*. In the same way the Drakensberg is considered to be an important migration route from the south for temperate species such as *Passerina montana*. This is paralleled by the spread of *Elytropappus*, *Euryops* and *Aster* in the south eastern Cape coastal regions from Humansdorp to the Amatole mountains (Acocks, 1953). Referring to the earlier extensive distribution of macchia, Rennie (1935) states, "Changing climatic conditions and the advance of the African (or Tropical) flora have led to the old temperate type on the mountains (of tropical Africa) as a series of relics". The extension of several Cape genera into the coastal districts of Pondoland and Natal and along the Drakensberg and the mountains of the Rhodesian border into East Africa, has frequently led to the assumption that the ancient migration of Cape flora to the north was essentially if not entirely along an eastern route.

Clearly the present day ecologist must distinguish between ancient relics and modern invasions when explaining the presence of macchia in the summer-rainfall area. While Clements (1934) was the first to explain the use of the "relict method" in ecology in detail, Lundegardh (1931) claims that, "The significance of relics is still very uncertain, they may in fact be outposts of an oncoming invasion". A knowledge of the habitat requirements is necessary for the intellegent application of the relic concept, a concept which becomes complicated when dealing with a genus such as *Passerina* which occurs under a 15″ rainfall near Windhoek (Rennie, 1935) and under a 79″ rainfall in the Natal Drakensberg (Killick, 1963).

Though no analysis has been made of the habitat conditions under which macchia is normally encountered in the summer-rainfall area, it is clearly correlated with high altitudes in most areas. Referring to the Cathedral Peak area of the Drakensberg, Killick (1963) emphasises the increasingly temperate character of the grassland with increase in altitude. The altitudinal zones in that area are also demarcated according to the importance of temperate species, e.g. Subalpine (6000′—9400′; *Passerina*, *Phillipia*, *Widdringtonia*), Alpine (9,400′—11,000′; *Erica*, *Helichrysum*). *Passerina montana* however occurs from 4,500′ to 10,000′ in that area, while Thoday (1924) reports it from 3000′ near King Williams Town.

Of the South African literature on the successional status of macchia, in various regions, the work of Story (1952) deserves special mention. In an attempt to unravel the successional and distributional patterns associated with *Cliffortia-Erica* macchia in the Amatole Mountains of the Eastern Cape, Story has written at length on the subject. His conclusions may be summarized as follows:

(*a*) The water requirements of macchia are greater than those of grassland and less than those of forest.
(*b*) Macchia ousts grassland from moist aspects.
(*c*) Fire destroys or effectively controls macchia and encourages grassland
(*d*) In the mid-altitudinal zones, grass is seral to macchia.
(*e*) Macchia is the climax at high altitudes (7300′) and seral to forest at mid-altitudes.
(*f*) Macchia does not occur in the drier lowlands (below 25″ rain).
(*g*) Indications are that *Passerina montana* cannot compete with the more robust *Cliffortia* and *Erica*.

Story's anatomical studies of the leaves of macchia vegetation support Thoday's (1921 and 1924) finding that these plants are well adapted to drought. The drought that these plants are subject to is usually of a physiological nature, due to non-availability of soil moisture resulting from the low temperatures which are common at the high altitudes at which macchia often occurs in the summer-rainfall area.

In view of the general assumption that members of the macchia communities have similar habitat requirements, the detailed investigations of Thoday (1924) are important. Working with six species of *Passerina* in the Cape, Thoday classified them all as gregarious pioneers. It was found that four of these were associated with specific different types of habitat, "defined largely in edaphic terms". "*Passerina montana* is distinctive morphologically, ecologically and geographically. It has the widest range of all, occurring from King Williams Town to the Northern Transvaal and near Umtali in Southern Rhodesia. Its occurrence in Southern Rhodesia raises wider questions of plant geography, for the nearest locality to the south is distant some four or five hundred miles".

DISCUSSION

Any serious consideration of the adaptation and distribution of communities with different climatic affinities must include an examination of the microclimate of the habitats concerned. In the case of temperate vegetation, the main features of the climate with which they are normally associated may be summarised as follows:

(*a*) a concentration of the reasonably low amount of precipitation in the winter, summers being almost or completely dry;

(*b*) warm to hot summers and very mild winters and

(*c*) a high percentage of the possible sunshine for the year, especially in summer. Such a climate characterises the southern Cape, with its macchia vegetation. Although the mean temperatures of the Hangklip area coincide with the Csb (warm temperate) climate as classified by the Köppen-Geiger system (1936), the dry winters distinguish this area from the Cape temperate climate. In order to explain the presence of communities dominated by temperate species with strong temperate affinities, the influence of physiographic factors on microclimate should be considered.

The author has adequately shown, from readings taken over a period of several years, that the mean temperature just above soil level is 6·7°F lower on the summit of a 2000′ mountain than at the base. In the same study it was shown that the mean temperatures on southern and eastern aspects were an average of 4·5°F lower than on northern and western aspects (Roberts, 1965). In the case of Hangklip the temperate communities are limited to the high-lying regions and the southern aspects at higher altitudes. It would thus appear that the temperate communities are associated with the cooler and moister conditions expected to result from the increase in altitude as well as from the oblique insolation on southern slopes, particularly during the winter.

ACKNOWLEDGEMENTS

The writer gratefully acknowledges the kind hospitality of Mr. J. Frost of

the farm "Sheran" during this study and the assistance of Mr. A. C. Evens in collecting and pressing plant specimens under difficult conditions. Thanks are also due to the staff of the National Herbarium for identification of certain specimens.

REFERENCES

Acocks, J. P. H., 1953, Veld types of South Africa. Bot. Surv. Mem. S.A. No. 28. Govt. Printer, Pretoria.

Bews, J. W., 1925. Plant Forms and the Evolution in South Africa. Longmans Green Co., London.

Bredenkamp, C. E., 1935. Origin of the flora of the central Kalahari. Ann. Transvaal Mus. 15: 443—455.

Clements, F. E., 1934, The Relect Method in Dynamic Ecology. J. Ecol. 22.

Köppen, W. & Geiger, R., 1936. Handbuch der Klimatologie. Bortraeger, Berlin.

Killick, D. J. B., 1963. An account of the plant ecology of the Cathedral Peak area of the Natal Drakensberg. Bot. Surv. Mem. S. Afr. No. 34. Govt. Printer, Pretoria.

Levyns, M. R., 1938. Some evidence bearing in the past history of the Cape Flora. Trans. Roy. Soc. S. Afr. 26: 401—424.

Lundegardh, H., 1931. Environment and Plant Development. Ed. Arnold, London.

Marloth, M., 1929. Remarks on the realm of the Cape Flora. S. Afr. J. Sc. 26: 154—156

Rennie, J. V., 1935. Flora of a High Mountain in South West Africa. Trans. Roy. Soc. S. Afr. 23: 259—263.

Roberts, B. R., 1963. A contribution to the ecology of Cathcart and environs with special reference to slope exposure and soil pH. J. S. Afr. Bot. XXIX: 153—162.

Roberts, B. R., 1965. Unpublished data.

Schimper, A. F. W., 1903. Plant Geography on a Physiological basis. Clarendon Press, Oxford.

Schonland, S., 1907. The origin of the flora of South Africa. Rep. S. Afr. Ass'n Sc. p. 105.

Schonland, S., 1909. A study of some facts and theories bearing upon the question of the origin of the Angiospermous Flora of S. Afr. Trans. S. Afr. Phil. Soc. XVII: 321.

Sim, T. R., 1920. Causes leading toward Progressive Evolution of the Flora of South Africa. S. Afr. J. Sc. 17: 51—64.

Story, R., 1952. A Botanical Survey of the Keiskammahoek District. Bot. Surv. Mem. S. Afr. No. 27, Govt. Printer, Pretoria.

Thoday, D., 1921. On the behaviour during drought of leaves of two Cape species of *Passerina*. Ann. Bot. 35: 585—602.

Thoday, D., 1924. The Geographical Distribution and Ecology of *Passerina*. Ann. Bot. 39: 175—207.

Warming, E., 1909. Oecology of Plants. Clarendon Press Oxford.

CYTOGENETIC STUDIES IN THE GENUS *ORNITHOGALUM* L.

III. MEIOTIC ANALYSIS OF SOME INTERSPECIFIC HYBRIDS OF *O. CONICUM* JACQ., AND *O. LACTEUM* JACQ.[1]

T. J. Roos[2] and R. de V. Pienaar[3]

ABSTRACT

The meiotic chromosome associations as well as the general course of microsporogenesis were investigated in the hybrids of three interspecific crosses involving *O. conicum* Jacq., *O. thyrsoides* Jacq., *O. lacteum* Jacq. and *O. flavissimum* Jacq. The aim was to collect information regarding the evolutionary relationship between these taxa.

The hybrid *O. conicum* (Ex Botanic Gardens, Stellenbosch) × *O. thyrsoides* (Bokbaai) was almost completely sterile. On backcrossing, however, a few seeds were set, indicating an incomplete barrier to gene exchange. These two species, therefore, bear an ecospecific relationship to one another. Due to a complete sterility of the hybrids between *O. conicum* (Ex Botanic Gardens, Stellenbosch) × *O. lacteum* (Darling), and *O. lacteum* (Darling) × *O. flavissimum* (Villiersdorp) the three parental species concerned must be regarded as cenospecies.

INTRODUCTION

Sexual reproduction and the accompanying meiotic mechanism play a fundamental role in the course of organic evolution. According to Darlington (1960) it forms a very stable mechanism by which new variation is created and slowly released. Genetic unbalance results whenever two chromosomes fail to pair and form chiasmata. The meiotic process takes place in a causal sequence that is universally maintained, namely chromosome pairing → crossing-over → chiasmata → segregation and reduction → sexual reproduction. Crossing-over is the event on which all the evolutionary processes converge, and out of which all the different forms diverge. Crossing-over of gene sequences, or nucleotide sequences, is the basic property of all systems capable of evolution, and sexual reproduction is the mechanism which, in association with crossing-over, has made the higher organisms possible.

Lewis (1957) pointed out that despite the diversity of factors interacting to produce a multitude of variation patterns, there are certain basic principles which permit a sound taxonomy. The most fundamental of these are the genetic discontinuity which results from evolutionary processes and the maintenance of this genetic integrity of the taxa by barriers to gene exchange. The isolating mechanisms operating in plants and animals are fully discussed by Clausen (1951), Dobzhansky (1951), Stebbins (1950) and others. All the cytogenetic work in the field of experimental taxonomy is therefore aimed at detecting the presence or absence of such barriers to gene exchange and, where appropriate, to determine the degree of gene exchange.

---

[1] Part of thesis submitted by the senior author in partial fulfilment of the requirements of the degree of M.Sc. in Agriculture at the University of Stellenbosch.

[2] Fruit and Food Technology Research Institute, Stellenbosch.

[3] Dept. of Genetics, S.E. College of Agriculture, Stellenbosch.

This view permits a better understanding of the species concept, which Dobzhansky (1951) defined as follows: "The species is not a static unit, but a stage in the process of evolutionary divergence. Species are formed when a once actually or potentially interbreeding array of Mendelian populations becomes segregated in two or more reproductively isolated arrays." A new species is therefore created when the evolutionary potential is limited to one single group.

It follows that geographical and ecological races, which are units immediately subordinate to the species level, play a fundamental role in speciation.

The pattern of ecotypic differentiation is not constant for all the species, and ecological isolation can occur in different ways. When once this isolation is effective and sufficiently prolonged, the difference between the major groups become so large that hybrids between them are completely sterile. This usually occurs as a result of changes in the genetic make-up and structure of the chromosomes, resulting in intra-generic differences.

Studies in gene-ecology and biosystematics were initiated by Turesson in 1922, but it is mainly due to the exhaustive contributions of Anderson, Babock, Cleland, Goodspeed, Gustafsson, Müntzing, Stebbins and others, especially Clausen, Keck and Hiesey since 1934, that this field has become an important branch of biology. The biosystematic categories of prime concern are the ecotype, ecospecies and cenospecies.

When there is no barrier to gene exchange between two separate ecological populations, that is, when the hybrids between them are completely fertile, they are termed ecotypes.

The status of ecospecies is reached when an incomplete barrier to gene exchange exists between the two populations. This partial barrier can either be due to genetic incompatability or hybrid sterility.

When there is a complete barrier to gene exchange between two populations, they bear a cenospecific relationship towards each other.

The ecospecies generally correspond to the species of classical taxonomy.

From the above considerations it would appear that experimental approaches in the lower ranks of classification can be of value in elucidating the apparent taxonomic confusion.

Leighton (1944–1945) distinguished 80 different indigenous *Ornithogalum* species in South Africa, but indicated that, due to intra-specific variation, the specific differences are not always clear cut.

In the current study a meiotic analysis was made of some *O. conicum* Jacq. and *O. lacteum* Jacq. hybrids to throw light on the genetic relationship between the taxa, especially because very few karyotypic differences could be detected by Pienaar (1963), and Roos and Pienaar (1966) (cf. fig. 1*a–d*).

MATERIALS AND METHODS

Reciprocal crosses were made, as shown in Table I, between the following biotypes of four *Ornithogalum* species: *O. conicum* Jacq. (Ex Botanic Gardens, Stellenbosch,) *O. thyrsoides* Jacq. (Bokbaai), *O. lacteum* Jacq. (Darling) and *O. flavissimum* Jacq. (Villiersdorp). The localities where the four species were collected are indicated on the map in the paper by Roos and Pienaar (1966). Flower buds of the three viable F_1 hybrids, viz. *O. conicum* × *O. thyrsoides*, *O. conicum* × *O. lacteum*, and *O. lacteum* × *O. flavissimum*, were fixed and treated according to the method of Pienaar (1955). P.M.C. staining proved very successful in the current material.

RESULTS

The results obtained from the reciprocal crosses between the biotypes of the four named *Ornithogalum* species are summarized in Table 1.

TABLE I

RESULTS OF INTERSPECIFIC CROSSES BETWEEN SOME *ORNITHOGALUM* SPECIES.

♂ Parent ♀ Parent	*O. conicum*	*O. flavissimum*	*O. lacteum*	*O. thyrsoides*
O. conicum	+	—	×	×
O. flavissimum	—	+	—	—
O. lacteum	S	×	+	—
O. thyrsoides	S	—	—	+

× = viable hybrids
— = no seed set
S = seed set but no viable hybrids produced
+ = pure bred plants

(*a*) The hybrid no. 387, viz. *O. conicum* (Ex Botanic Gardens, Stellenbosch) × *O. thyrsoides* (Bokbaai) produced only a few pollen grains of normal appearance; most of which were 2 × (Fig. 1 *i*).

The data from a comparative study of the pollen of the hybrids with the pollen of the parents are summarized in Table II.

Table II

Number of apparently viable (carmine stained) and inviable pollen grains, and the diameter of "viable" pollen, measured in μ.

Plant	Number of pollen grains counted	Number of stained pollen grains	% of "viable" pollen grains	Mean diameter (μ)	Standard deviation
O. conicum (Botanic Gardens, Stellenbosch)	518	501	96·7	63	± 2·5
O. thyrsoides (Bokbaai)	533	512	96·1	55	± 3·5
O. conicum × *thyrsoides* (No. 387)	499	53	10·6	78*	±11·3
O. lacteum (Darling)	520	502	96·5	55	± 3·5
O. conicum × *lacteum* (No. 390)	530	16	3·0	61	± 5·8
O. flavissimum (Villiersdorp)	556	546	98·2	45	± 3·5
O. lacteum × *flavissimum* (No. 1045)	552	49	8·9	72	± 6·5

* In a subsequent measurement of 178 stained grains it was found that 26·7% pollen grains have a diameter between 60–70 μ, 10·5% a diameter between 70–80 μ, 14% a diameter between 80–90 μ, 44·2% a diameter between 90–100 μ, and 4·6% a diameter over 100 μ.

From Table II it is evident that hybrid no. 387 produced only about 11% stained, apparently viable pollen grains. About 66·3% of the hybrid's "viable" pollen grains was approximately twice the volume of the parents' (Table II foot note, and Fig. 1 *h–j*.), and since it is known that polyploidy induces a direct increase in cell volume, it was assumed that this proportion of the hybrid's "viable" pollen grains was diploid. Since the volume of the remaining 33·7% of the "viable" pollen grains approximately equalled that of the parents', they were considered to be haploid. The pollen of this hybrid, therefore, appeared to be a mixture of diploid and haploid pollen grains; this can explain the rather high standard deviation of 11·3 in the pollen grain measurements listed in Table II.

All the P.M.C.'s which entered meiosis were diploid and no apparent abnormalities were detected during anaphase I. In most of the cells meiosis was quite normal resulting in tetrads of four haploid microspores (Fig. 1 *g*). Except for the delayed onset of the second meiotic division in some of the diads no meiotic abnormalities were detected which could give rise to the high frequency of diploid pollen grains. A preliminary investigation of pollen grain development has as yet failed to throw light on this phenomenon.

TABLE III

CHROMOSOME ASSOCIATIONS AND CHIASMA FREQUENCIES AT MI OF THE F_1 HYBRID *O. CONICUM* (BOTANIC GARDENS, STELLENBOSCH) × *O. THYRSOIDES* (BOKBAAI)

Chromosome associations			Number of cells scored	Number of chiasmata per cell	Standard deviation	Mean number of chiasmata per chromosome pair
I	II	III				
	6		8	10·8	±0·90	1·8
2	5		7	9·0	±2·10	1·5
4	4		3	7·3	±0·50	1·2
Total			18	M=9·6	±2·0	1·5

The mean number of 9·6 chiasmata per cell is indicative of a high degree of genetic homology between the genomes of the two parental species (Tables III and IV, Fig. 1*e* and *f*).

The occurrence of a few univalents, as well as the partial reduction in the chiasma frequency compared to that found in natural *O. thyrsoides* (Table IV), indicate, however, that some genetic divergence has occurred.

TABLE IV

CHROMOSOME ASSOCIATIONS AND CHIASMA FREQUENCIES AT MI OF *O. THYRSOIDES* FROM SANDVELD

Chromosome associations			Number of cells scored	Number of chiasmata per cell	Standard deviation	Mean number of chiasmata per chromosome pair
I	II	III				
	6		16	12·9	±1·22	2·2
2	5		4	12·3	±0·47	2·1
Total			20	M=12·7	±1·19	2·10

(*b*) Hybrid no. 390, which resulted from the cross *O. conicum* (Ex Botanic Gardens, Stellenbosch) × *O. lacteum* (Darling) (cf. Pienaar, 1963) was almost completely sterile. Data concerning the size and viability of pollen grains are summarized in Table II.

The few "viable" pollen grains that were produced appeared normal and haploid and were about the same size as those of the parents (Fig. 2*h*).

No abnormalities could be detected prior to diakinesis and the pairing of chromosomes was almost complete (Fig. 2*a* and *b*). A few univalents and only one quadrivalent were observed in the material. A detailed analysis of metaphase I cells is given in Table V.

Table V

Chromosome associations and chiasma frequencies at MI of the F_1 hybrid *O. CONICUM*(ex botanic gardens, stellenbosch) × *O. LACTEUM* (darling)

Chromosome associations				Number of cells scored	Number of chiasmata per cell	Standard deviation	Mean number of chiasmata per chromosome pair
I	II	III	IV				
	6			31	14·5	± 0·6	2·4
2	5			9	12·7	± 0·6	2·1
1	4	1		1	12·0	—	2·0
	4		1	1	12·0	—	2·0
4	4			5	10·6	± 1·2	1·8
2	3		1	1	12·0	—	2·0
6	3			2	6·0	± 0·0	1·0
Total				50	M=11·4	± 0·6	1·9

Anaphase I was also normal, although a few cells were noted with lagging chromosomes. These, however, were very infrequent. All the later stages appeared to be normal, resulting in apparently normal haploid tetrads.

The differentiation of the pollen grains, however, was rather abnormal. The protoplasmic contents of the microspores commenced to contract at an early stage and soon afterwards degenerated. This irregular behaviour was so frequent that almost 97% of the microspores degenerated, leaving only empty shells (Table II and Fig. 2*h*).

(*c*) The cross *O. lacteum* (Darling) × *O. flavissimum* (Villiersdorp) produced F_1 hybrid no. 1045. Measurements of the pollen grains are summarized in Table II; the mean diameter of 72 μ for the "viable" pollen grains revealed a diploid state (Fig. 2*i*). It was noted that about one quarter of the microsporocytes was polyploid before meiosis commenced. The endomitotic divisions giving rise to these polyploid P.M.C.'s could not be detected.

The normal diploid microsporocytes revealed quite a normal synaptic behaviour resulting mostly in bivalents with readily detectable chiasmata at diakinesis and M.I. (Fig. 2*c* and *d*). In the polyploid cells, however, univalents as well as multivalents were formed, which eventually led to an unbalanced segregation of the chromosomes. An analysis of chiasmata in these polyploid cells were very difficult, due to the overlapping and clumping of the chromosomes, but in a number of cells their tetraploid nature was quite evident (Fig.

2*e* and *f*). In some instances, however, microsporocytes were noted that had 12 bivalents, (Fig. 2*e*) and they probably would have completed a normal meiosis resulting in the production of diploid pollen grains.

Table VI summarizes the meiotic analysis of this hybrid.

Table VI

Chromosome associations and chiasma frequencies at MI of the F_1 hybrid of *O. LACTEUM* (Darling) × *O. FLAVISSUM* (Villiersdorp)

Chromosome associations				Number of cells scored	Number of chiasmata per cell	Standard deviation	Mean number of chiasmata per chromosome pair
I	II	III	IV				
(a) *Tetraploid*							
	12			8	23·7	±0·54	1·9
2	11			1	22·0	—	1·9
	10		1	3	22·7	±0·47	1·9
Total				12	M=22·8	±0·51	1·9
(b) *Diploid*							
	6			29	12·2	±0·85	2·0
2	5			5	9·6	±0·48	1·6
4	4			4	9·0	±1·00	1·5
Total				38	M=10·6	±0·71	1·8

The post-meiotic development of pollen grains was similar to that of the other hybrids described. About 91% of the microspores degenerated, leaving 9% surviving pollen grains, all of which were diploid (Fig. 2*i*).

DISCUSSION

Sympatric, sexually reproducing populations can only be kept intact when gene exchange is limited or prevented by intrinsic genetically conditioned properties, i.e. reproductive isolation. The isolating mechanism can operate in different ways and in the current *Ornithogalum* material it appears that hybrid sterility plays a major part in isolating the different taxa.

According to Dobzhansky (1951) hybrid sterility is due to a specific incompatability of the parental gene complexes active during meiosis and in post-meiotic development of gametes. He also distinguishes between genic sterility and chromosomal sterility. In the former instance all the meiotic abnormalities such as poor spindle formation and irregular asynapsis and desynapsis are controlled by the genes. Chromosomal sterility is a consequence of an absence or

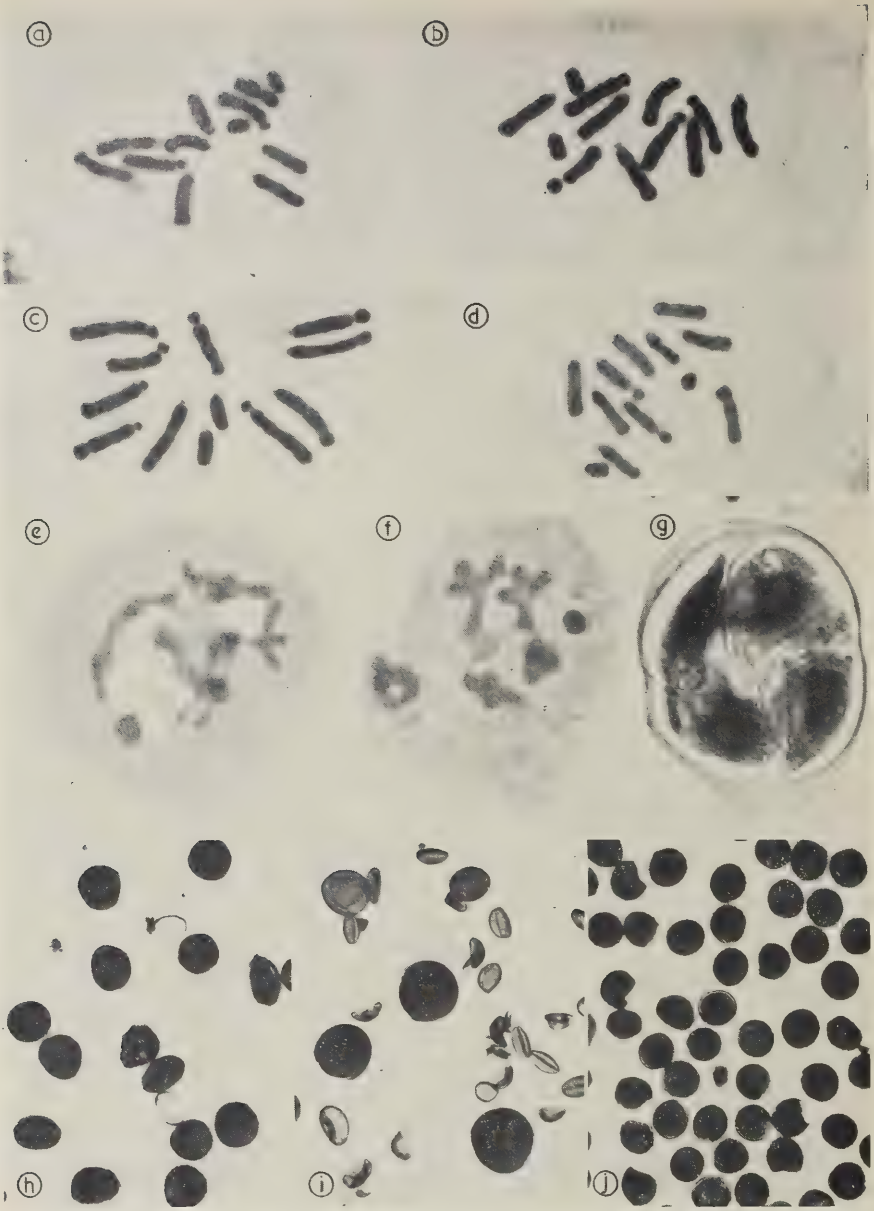


FIG. 1. (*a–d*) C-mitoses in root tip cells of *Ornithogalum*, × 2000: (*a*) *O. conicum* (Clanwilliam); (*b*) *O. thyrsoides* (Bokbaai), (*c*) *O. lacteum* (Darling); and (*d*) *O. flavissimum* (Villiersdorp). (*e–g*). Meiotic stages in hybrid no. 387, viz., *O. conicum* (Ex Botanic Gardens, Stellenbosch) × *O. thyrsoides* (Bokbaai); (*e*) and (*f*) diakinesis, × 1500; (*g*) Mature tetrad, × 1500. (*h–j*) Mature pollen grains stained with glycerine-acetocarmine, × 250: (*h*) *O. conicum* (Ex Botanic Gardens, Stellenbosch); (*i*) the hybrid no. 387, viz., *O. conicum* (Ex Botanic Gardens Stellenbosch) × *O. thyrsoides* (Bokbaai); and (*j*) *O. thyrsoides* (Bokbaai).

reduction of chromosomal homology, that is a mechanical incapacity of normal synapsis.

Stebbins, Valencia and Valencia (1946), however, are of the opinion that no apparent distinction between genic and chromosomal sterility is possible. Greenleaf (1941) showed that in the hybrid *Nicotiana sylvestris* x *N. tomentosiformes* both these mechanisms work together in producing hybrid sterility.

Nielson (1962) believes that another very important mechanism which regulates fertility, is the balance between the nucleus and the surrounding cytoplasm. Foreign chromatin in the mother cytoplasm results in a disturbance of the normal physiological processes and gives rise, therefore, to sterility.

Because of the fairly normal course of meiosis in the three *Ornithogalum* hybrids described (*O. conicum* × *O. thyrsoides*, *O. conicum* × *O. lacteum* and *O. lacteum* × *O. flavissimum*), independent segregation of the chromosomes of the parental species leads to the formation of haploid spores having various combinations of parental chromosomes; such combinations constitute unbalanced genomes which cannot operate normally in the cytoplasm contributed by the female parental species, and the differentiating spores consequently abort. The greater the genomic differences between the parental species, or the structural hybridity, the greater will be the genic and/or nuclear cytoplasmic unbalance in the spores, with a consequent increase in sterility. In the extreme case only those spores receiving a full normal haploid genome of especially the female parental species (which is a very unlikely event), or an unreduced diploid chromosome complement made up of the genomes of both species, can be expected to function. The rare stainable grains in the hybrid *O. conicum* × *O. lacteum* may have resulted from the former event, whereas the large apparently functional diploid pollen grains produced by some *Ornithogalum* hybrids (*O. lacteum* × *O. flavissimum*) can be accounted for on the latter grounds.

The genetic divergence between *O. conicum* (Ex Botanic Gardens, Stellenbosch) and *O. thyrsoides* (Bokbaai) has not continued far enough to cause complete sterility. Although these two species are capable of being crossed, and back crossed with a very limited amount of seed set, chromosomal and genic sterility prevent the free exchange of genes to a large extent. With respect to each other they, therefore, constitute two ecospecies.

The hybrid *O. conicum* (Ex Botanic Gardens, Stellenbosch) × *O. lacteum* (Darling) revealed an apparently normal meiosis. Despite this, the pollen is almost completely inviable, indicating a high degree of nuclear-cytoplasmic unbalance, or genic relative to chromosomal sterility. Gene differences and/or differences in small fragments of the chromosomes, referred to by Stebbins

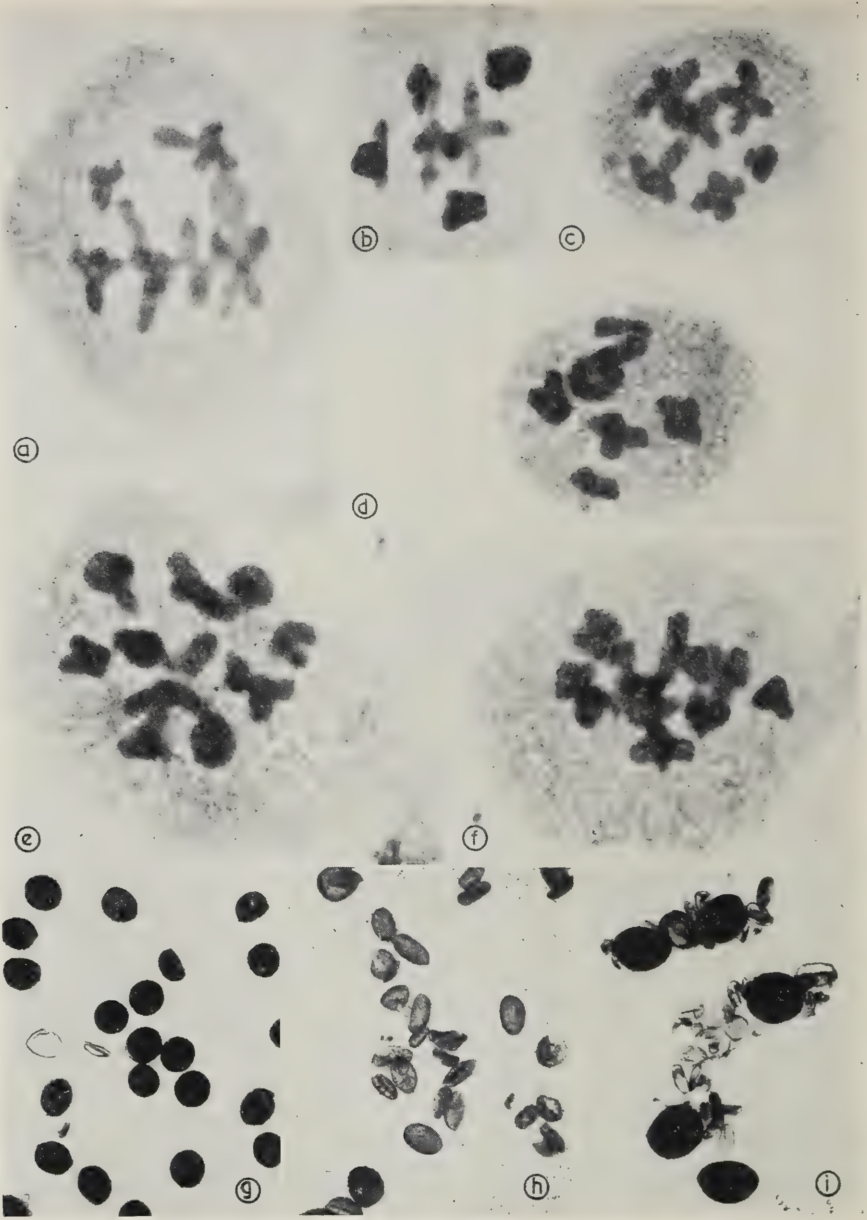


FIG. 2 (*a* and *b*) Meiotic stages in hybrid no. 390, viz., *O. conicum* (Ex Botanic Gardens, Stellenbosch) × *O. lacteum* (Darling): (*a*) Diakenisis, × 1500; (*b*) Metaphase I, × 1500. (*c–f*) Meiotic stages in hybrid no. 1045, viz., *O. lacteum* (Darling) × *O. flavissimum* (Villiersdorp); (*c*) and (*d*) Early Metaphase I in diploid P.M.C.'s, × 1500; (*e*) and (*f*) Metaphase I in tetraploid P.M.C.'s, × 1500. (*g–i*) Glycerine-acetocarmine stained mature pollen grains, × 250; (*g*) *O. lacteum* (Darling); (*h*) hybrid no. 390, viz., *O. conicum* (Ex Botanic Gardens, Stellenbosch) × *O. lacteum* (Darling); and (*i*) hybrid no. 1045, viz., *O. lacteum* (Darling) × *O. flavissimum* (Villiersdorp).

(1945) as "cryptic structural hybridity", leading to the formation of genetically unbalanced, inviable spores, could basically be responsible for the observed sterility. Such presumed unbalanced gene complexes at the haploid level on the one hand, and the interaction between the foreign chromatin and the maternal cytoplasm (Nielson, 1962) on the other, reduces the viability of the pollen grains to such an extent that no gene exchange is possible between these two species. Consequently, with respect to each other, *O. conicum* and *O. lacteum* must be regarded as two good cenospecies.

Similarly, due to the incapacity of gene exchange between *O. lacteum* (Darling) and *O. flavissimum* (Villiersdorp), and, as shown in Table I, between *O. lacteum* (Darling) and *O. thyrsoides* (Bokbaai), between *O. conicum* and *O. flavissimum* (Villiersdorp), and between *O. flavissimum* (Villiersdorp) and *O. thyrsoides* (Bokbaai), they bear a cenospecific relationship towards each other. In short, they are all good species in the classical taxonomic sense.

ACKNOWLEDGEMENTS

The authors are indebted to the Department of Agricultural Technical Services for making this study possible.

REFERENCES

CLAUSEN, J., 1951. Stages in the Evolution of Plant Species. Hafner Publ. Co., N.Y.

CLAUSEN, J., KECK, D. D. & HIESEY, W. M., 1947. Heredity of geographically and ecologically isolated races. *Amer. Nat. Vol.*, **81**: 114–133.

DARLINGTON, C. D., 1960. Chromosomes and the theory of heredity. *Nature, Vol.* **187**: 892–895.

DOBZHANSKY, T., 1951. Genetics and the Origin of Speices. 3rd revised Ed. Columbia Univ. Press, New York.

GREENLEAF, W., 1941. Sterile and fertile amphidiploids. Their possible relation to the origin of *Nicotiana tabacum. Genetics*, **26**: 301–324.

LEIGHTON, F. M., 1944. A revision of the South African species of *Ornithogalum* L. Part I. *Journ. S. Afr. Bot.*, **X**: 83–110.

——— 1944. Part II. *Journ. S. Afr. Bot.*, **X**: 111–122.

——— 1945. Part III. *Journ. S. Afr. Bot.*, **XI**: 135–189.

LEWIS, H., 1957. Genetics and cytology in relation to taxonomy. *Taxon.*, **6(2)**: 42–46.

NIELSEN, E. L., 1962. Analogies in the nature and occurrence of sterility in plants. *Crop Science, Vol.* **2**: 181–185.

PIENAAR, R. DE V., 1955. Combinations and variations of techniques for improved chromosome studies in the *Gramineae. Journ. S. Afr. Bot.*, **XXI**: 1–9.

——— 1963. Sitogenetiese studies in die genus *Ornithogalum* L. I. Inleidende oorsig. *Journ. S. Afr. Bot.*, **XXIX**: 111–130.

ROOS, T. J. & PIENAAR, R. DE V., 1966. Cytogenetic studies in the genus *Ornithogalum L.* II. Karyotype analyses in some biotypes of *O. conicum Jacq., O. lacteum Jacq.*, and *O. thyrsoides. Journ. S. Afr. Bot.*, **32**: 211—227.

STEBBINS, G. L., 1945. The cytological analysis of species hybrids. *Bot. Rev.*, **11**: 463–486.

——— 1950. Variation and Evolution in Plants. Columbia Univ. Press, N.Y.

VALENCIA, J. I. & VALENCIA, R. M., 1946. Artificial and natural hybrids in the *Gramineae*, tribe *Hordeae*. I. *Elymus*, *Sitanion* and *Agropyron*. *Amer. J. Bot.*, **33**: 338–351.

TURESSON, G., 1922. The genotypical response of the plant species to the habitat. *Hereditas*, **3**: 341–347.

STUDIES IN STREPTOCARPUS III: THE STREPTOCARPUS FANNINIAE ALLIANCE*

O. M. HILLIARD
(*Bews Botanical Laboratories, University of Natal, Pietermaritzburg*).

This is the third in a series of papers on the subgenus* Streptocarpus *in South East Africa. It should be read in conjunction with the introduction to the first paper (Hilliard,* **Jnl. S. Afr. Bot. 32, 1).

S. fanniniae and its allies range from the mountains of Swaziland and the eastern Transvaal through the higher regions of Natal to the mountains of the eastern Cape. *S. fanniniae* itself is confined to Natal and Zululand forests at altitudes of between 900 and 1500 m. It is closely allied to *S. candidus*, so far known only from Ngome forest (900 to 1200 m.),[1] and to *S. wilmsii* which extends from Mbabane, Swaziland, along the mountains of the eastern Transvaal to Mariepskop, in forest patches between 1200 and 1650 m. in altitude. *S. pusillus* is confined to the Drakensberg and its outliers from the Orange Free State around Harrismith through Natal and the Basutoland border to the eastern Cape. It has close affinity with *S. davyi*, endemic to Swaziland, where it is common around Mbabane. The latter two species are found in the shelter of rock outcrops, although *S. pusillus* sometimes grows in forest.

That these five species form a natural alliance is not immediately apparent; it is largely diversity in growth form among the species that is misleading. A more critical inspection shows, however, that in addition to certain androecial and gynoecial characters in common, the species display a number of other unifying features, notably corolla form and patterning, and, in some of the species, a distinctive type of branching of the floral axis.

The strong floral resemblance between *S. pusillus* and *S. davyi* is striking, and that between *S. candidus* and *S. wilmsii* is so marked that flowers of the former species are most easily distinguished by the violet-coloured inverted vees at the base of the lower lip. The corollas of all four species are much the same shape and it is only disparity in size that creates an illusion of dissimilarity between the species pairs. Corolla shape in *S. fanniniae* differs from that of the others mainly in the two upper lobes being porrected instead of reflexed.

---

[1] Since this was written, *S. candidus* has been collected at two other localities in Natal: Mahlabatini dist., Ceza, *Burtt and Hilliard* 3296, E, NU; Vryheid dist., Nhlazatshe Mt., *Burtt and Hilliard 3332*, E, NU.

In *S. fanniniae*, the flowers are often pale blue, though whitish forms are frequent. Those of the other species generally have a white ground, but the corolla of *S. wilmsii* is often suffused violet-blue and there is one report of some mauve specimens in a population of *S. pusillus*. But ground colour in *Streptocarpus* generally is without much taxonomic significance. Of greater import is the type of patterning on the corolla.

Both *S. wilmsii* and *S. candidus* have a yellow stripe and violet spots on the floor of the corolla tube. In *S. fanniniae*, the floor of the tube is nearly always spotted, occasionally striped, violet, and the two keels in the throat are often yellow. The corolla tube in both *S. davyi* and *S. pusillus* is immaculate and although yellowing in the throat or on the floor of the tube has never been recorded in *S. pusillus*, it is sometimes present in *S. davyi*.

The relationship between *S. candidus*, *S. wilmsii* and *S. fanniniae* is further emphasized by their having an identical perfume.

The close affinity of *S. pusillus* and *S. davyi* and of *S. wilmsii* and *S. candidus* is undoubted. *S. fanniniae* on the other hand shares some floral characters including perfume with the first species pair, and with the second pair, not only floral characters, but also a unique pattern of branching of the floral axis, unique, that is, among the South African representatives of the subgenus, although a tendency towards this type of branching can sometimes be seen in *S. bolusii*, in an undescribed Transvaal species allied to *S. bolusii*, and in *S. rimicola*. The same pattern is evident in some Tropical African species, notably *S. bullatus* from Tanganyika.

Because of close floral resemblance among the species, the most reliable and most easily applied diagnostic criterion for separating the closely allied species is habit, the very feature that creates an illusion of dissimilarity in the alliance. *S. wilmsii* is unifoliate and generally monocarpic but shows a tendency towards the production of accessory leaves, *S. candidus* is rosulate and perennial, *S. fanniniae* is perennial with a unique system of creeping, branching petioles, *S. pusillus* is monocarpic and usually two- to three-leaved, and *S. davyi* is several-leaved and perennial.

GENERAL CHARACTERISTICS OF S. FANNINIAE ALLIANCE

Herbs, sometimes stemless, but three species with erect flowering axes, monocarpic or perennial, terrestrial or epiphytic. *Leaves* 1 to numerous, apex usually withered, margin crenate, upper surface rugulose, veins impressed above, prominent below. *Inflorescences* cymose, several in acropetal succession from base of midrib or apex of petiole. *Calyx* 5-partite. *Corolla* bilabiate, *tube relatively broadly subcylindric, mouth cylindric, limb almost straight*, patterning, if present, of bluish-violet spots or streaks, often associated with one or two yellow stripes, on floor of tube and base of lower lip, upper lip 2-lobed, lower 3-lobed. *Stamens:* fertile 2, included, inserted one-third up corolla tube, filaments white, twisted, curved, curve dilated, *usually conspicuously toothed at junction with connective;* anthers introrse, lobes 2, applanate; staminodes often very conspicuous. *Disc* annular, orange. *Ovary* terete; *style dorso-ventrally compressed, approximately equal in length to ovary; stigma of two unequal, reniform, papillose lips* (lips occasionally obscure in *S. davyi*) held in the median plane. *Capsule relatively short with a prominent apiculus.*

KEY TO *S. FINNINAE* ALLIANCE

1a	Flower up to 25 mm. long.	2
1b	Flower longer than 25 mm.	3
2a	Plant monocarpic, consisting of one leaf, often with a second (and occasionally third) petiolate leaf developing sympodially from the petiole of the primary leaf	5. *S. pusillus*
2b	Plant perennial with the same growth pattern as above, but in addition several accessory leaves at base of primary petiole	4. *S. davyi*
3a	Leaf usually one, very occasionally one or two much smaller leaves at base of primary leaf, base cordate to cuneate	2. *S. wilmsii*
3b	Leaves several, base cuneate	4
4a	Plant with a unique system of creeping, branching, rooting petioles; each leaf developing accessory leaves, often in pairs, from its petiole	1. *S. fanniniae*
4b	Leaves arranged in a rosette	5
5a	Corolla white, lower lip marked with two deep violet inverted vees	3. *S. candidus*
5b	Corolla pale bluish-violet, lower lip marked with deep violet, interrupted lines, upper lobes with strong median lines	1. Putative *fanniniae* × *gardenii*

1. **S. fanniniae** Harv. ex C.B. Cl. in DC. Monog. Phan. 5:150 (1883); C.B. Cl. in Fl. Cap. 4(2):444 (1904); B. L. Burtt in R.H.S. Dict. Gard. ed. 2, 4:2044 (1956). Natal, Dargle Farm near Umgeni river, *Mrs. Fannin* 55, K, HOLOTYPE, NH, TCD, ISOTYPES.

Var. β minor C.B. Cl. in DC. Monog. Phan. 5:151 (1883), Natal, sine loc., *Mrs. Saunders* s.n., K, HOLOTYPE. *S. woodii* C.B. Cl in Dyer, Fl. Cap. 4(2):445 (1904); B. L. Burtt in R.H.S. Dict. Gard. ed. 2, 4:2045 (1956). Natal, "Liddesdale", *Wood* 3931, K, NH, Noodsberg, *Wood* 4234, K, NH, Ixopo, Entalramu, *Mrs. E. S. Clarke* s.n., BM, K, SYNTYPES.

Perennial herb with elongate, erect flowering axes, and creeping, rooting petioles. *Leaves* numerous, up to 900 × 220 mm., often smaller, base cuneate, upper surface green, glossy, sparsely pilose becoming glabrescent, lower paler,

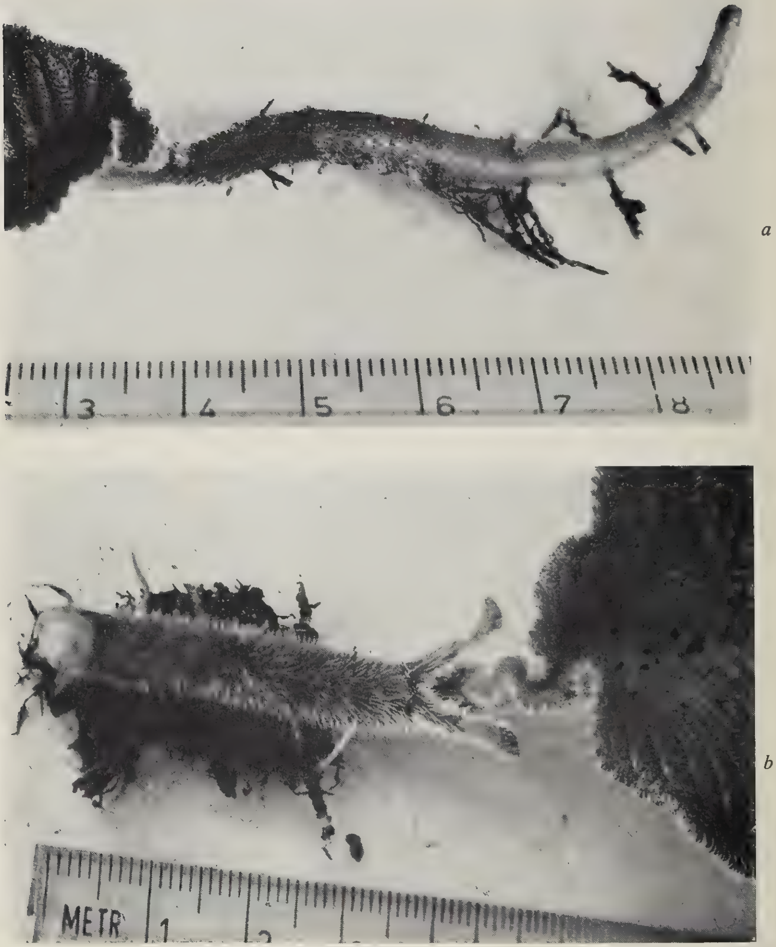
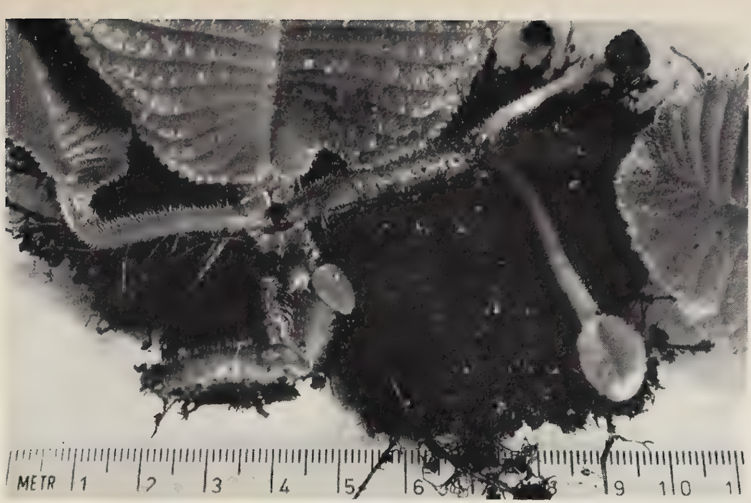


Plate 1

Parts of plants of *S. fanniniae*. (*a*) leaf with elongated, rooting petiole. Primordia of two pairs of accessory leaves can be seen, the first immediately below the junction of lamina and petiole, the second about 3 cms below the first. (*b*) A similar leaf with petiole and lamina of an apical pair of accessory leaves now differentiated. (*c*) later stage in growth with petioles of accessory leaves elongated and rooting. One accessory petiole has itself produced a second pair of leaves. (*d*) erect flowering axis which can be produced by any leaf (see text, p. 280 and Plate 2c). *a–c* scale in cms, *d*, about half natural size.



c

d

glabrescent, veins pilose; petiole stout, of indeterminate length, up to 15 mm. in diam., creeping, rooting, green of reddish-brown, pilose. *Inflorescences* from apex of petiole and base of midrib, many flowers expanded simultaneously. *Peduncle* up to 300 mm. long, green, pilose with glandular and eglandular hairs. *Bracts* elliptic, up to 12 × 4 mm., green, sparsely pilose. *Flower* 28—40 mm. long, honey-scented. *Pedicel* 14 mm. long, elongating slightly in fruit, pale purplish-red, densely glandular, sparsely pilose. *Calyx* lobes linear, 10 × 1·5 mm., green to purplish, glandular-pilose. *Corolla* tube slightly curved, whitish below, pale blue above, glandular-pilose, 18—23 mm. long, throat 7—9 mm. in diam.; upper lobes porrected, suborbicular, 6—8 × 7—9 mm.; lower lip porrected, 15—18 mm. long, lobes elliptic to suborbicular, 5—10 × 5—10 mm.; all lobes whitish, sparsely glandular outside, pale blue, glabrous inside, with 2 keels extending from base of anterior lobe into throat and along floor of tube. *Stamens:* filaments 9 mm. long, white, abruptly curved, curve dilated, sparsely glandular; anther lobes 1·5 mm. long, yellow, glandular; posterior staminode minute, laterals 6 mm. long, obscurely bifid, white, glandular. *Ovary* 8 mm. long, white, pilose with glandular and eglandular hairs; style 6 mm. long, white, sparsely glandular or glabrous. *Capsule* 30—62 (47 ± 7) mm. long, 2 mm. in diam.

Flowering period: November to April.

NATAL: Ngotshe dist., Ngomi forest station, *Codd* 9596, PRE; Ingoma (Ngome), *Gerrard* 1980, TCD; Ngome forest, c. 1200 m., *Hilliard* 866, K, NU. Vryheid dist., Vryheid east, *Gerstner* s.n., NBG 881/35. Nkandla dist., Nkandla forest, 1070 m., *Hilliard* 916, NU; Qudeni forest, *Fisher and Schweickerdt* 112, NH, NU, PRE, do., *Gerstner* 2859, K, NH, PRE. Umvoti dist., near Lilani, 930 m., *Hilliard* 842, NU; near Ahrens, farm "Mowbray", *Fisher* 963, NU; Lions River dist., near Dargle Farm, Umgeni [river], *Hallack* 2, TCD; Lidgetton, *Wood* 6302, BM (mixed gathering), K, PRE; farm "The Dargle", 1524 m., *Hilliard* 1212, E, K, NU; Dargle, farm "Kilgobbin", 1310 m., *Hilliard* 847, E, NBG, NU; near Howick, farm "Gowan Brae" ("Liddesdale"), 1370 m., *Hilliard* 858, E, K, NU. Mapumulo dist., 7 mls. Mapumulo village en route Kranskop, *Tinley* s.n., NU; Pietermaritzburg dist., Sevenfontein, 9—1200 m., *Wylie* com. *Wood* 8121, GRA. Richmond dist., Richmond, Enon forest, *Hilliard* 2030, NU.

S. fanniniae is widespread in the Natal Midlands and parts of Zululand at altitudes ranging from 900 to 1500 m. It is found only in well illuminated forest along streams or seepage lines either rooted in very damp soil or creeping over rocks in the streambed, or clinging to wet rock faces at waterfalls and cascades. The vegetative growth form is quite unlike that of any other South African species. The cotyledonary leaf becomes petiolate, which is not in itself unusual,

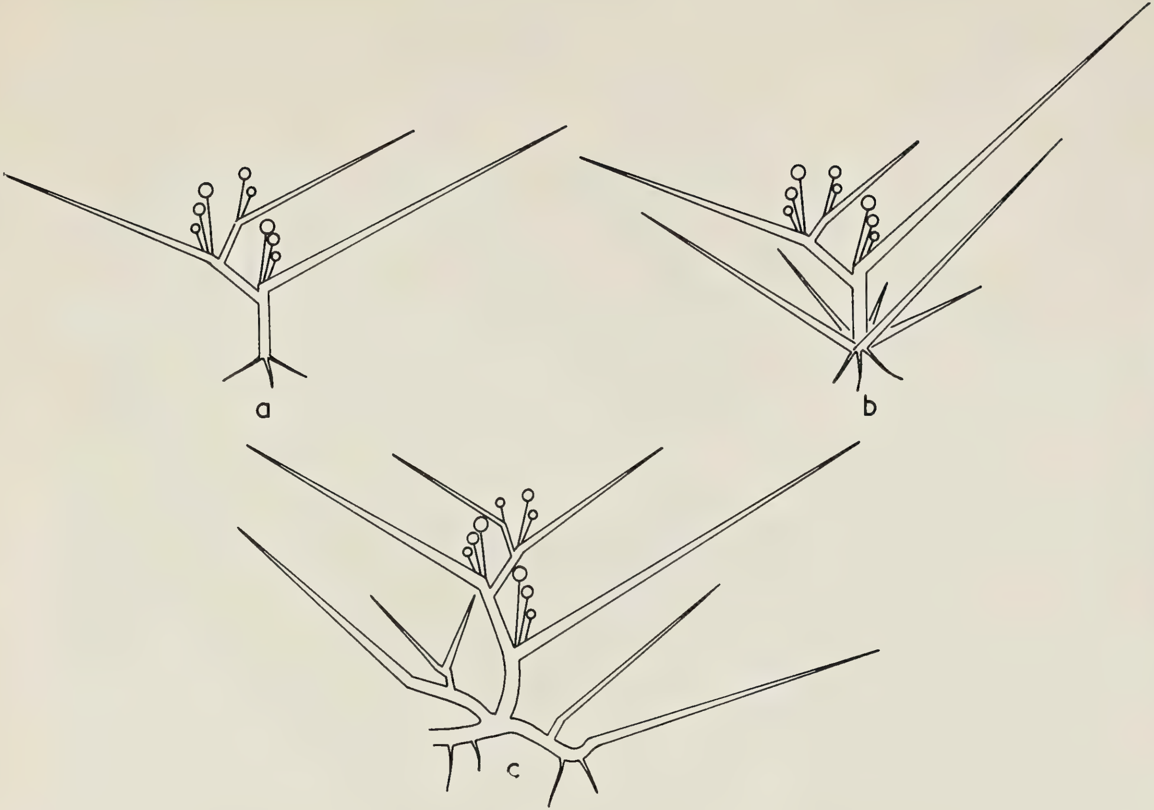


PLATE 2

Schematic diagram to show growth patterns in (*a*) *S. pusillus* (whole plant), (*b*) *S. davyi* (whole plant) and (*c*) *S. fanniniae* (part of plant). See text for discussion. (Drawings not to scale.)

but the petiole elongates considerably and one or two petiolate accessory leaves develop near its apex. The primary cotyledonary leaf and accessory leaves are soon indistinguishable. The petioles continue elongating and thickening and adventitious roots develop wherever they touch the ground. Further leaves develop from the petioles, which may branch, spreading over the surface of soil or rock, clinging tenaciously by the adventitious roots. Dense tangles of rooted leaves result. (Plate 1a-c). Inflorescences develop from the apex of the petiole and the base of the midrib of a flowering leaf. Several petiolate flowering leaves may develop sympodially from the apex of an initial flowering petiole. (Plates 1d and 2c). The flowering leaves are held erect, and only the petiole at the base of the flowering axis is rooted. A flowering branch may reach a metre in height. Within any population, there is some variation in size of the corolla tube, shape and size of the corolla lobes, colour, and markings on the floor of the corolla tube. (Plate 3). Variation between populations can be even more marked. Plate 4 illustrates variation in corolla shape between several populations. Colour and markings can be very variable too. For example, near Howick on the farm "Liddesdale" (now "Gowan Brae" and one of the type localities of *S. woodii*) corolla colour varies from almost white to pale blue, and the keels on the floor of the tube are pale blue flanked by deep violet, interrupted lines. At Lilani, not far from the Noodsberg, the corolla is very pale blue, the keels yellow flanked by deep violet splotches. Populations on the farm "The Dargle", near the source of the Umgeni river, have pale blue to whitish corollas, the keels pale yellow or whitish, spotted violet. On nearby "Kilgobbin" the keels are sometimes replaced by deep violet lines on the floor of the corolla tube, a feature noticed also in populations at Karkloof and Sevenoaks.

Because of this variation, it is impossible to maintain *S. woodii*, distinguished from *S. fanniniae* mainly on corolla colour and dimensions. Clarke's other character, pollen-grain shape, is invalid because all the pollen grains are ellipsoid when dry, globose when wet.

Despite corolla variation, *S. fanniniae* is very distinctive, and it it not easily confused with any other species. Its affinities lie with *S. candidus* and *S. wilmsii*. All three species are very similar floristically, but differ markedly in growth pattern. *S. candidus* is rosulate and perennial, *S. wilmsii* solitary-leaved and usually monocarpic, and *S. fanniniae* perennial with a unique system of branching rooting petioles that give rise to accessory leaves, and with erect, elongate flowering axes. The flowers of all three smell sweetly of honey, a notable feature in an almost scentless genus, and one which draws attention to the still unsolved problem of natural pollinators. The frequency of natural interspecific hybridisation in the subgenus stresses the likelihood of insect pollination being a factor in the breeding system.

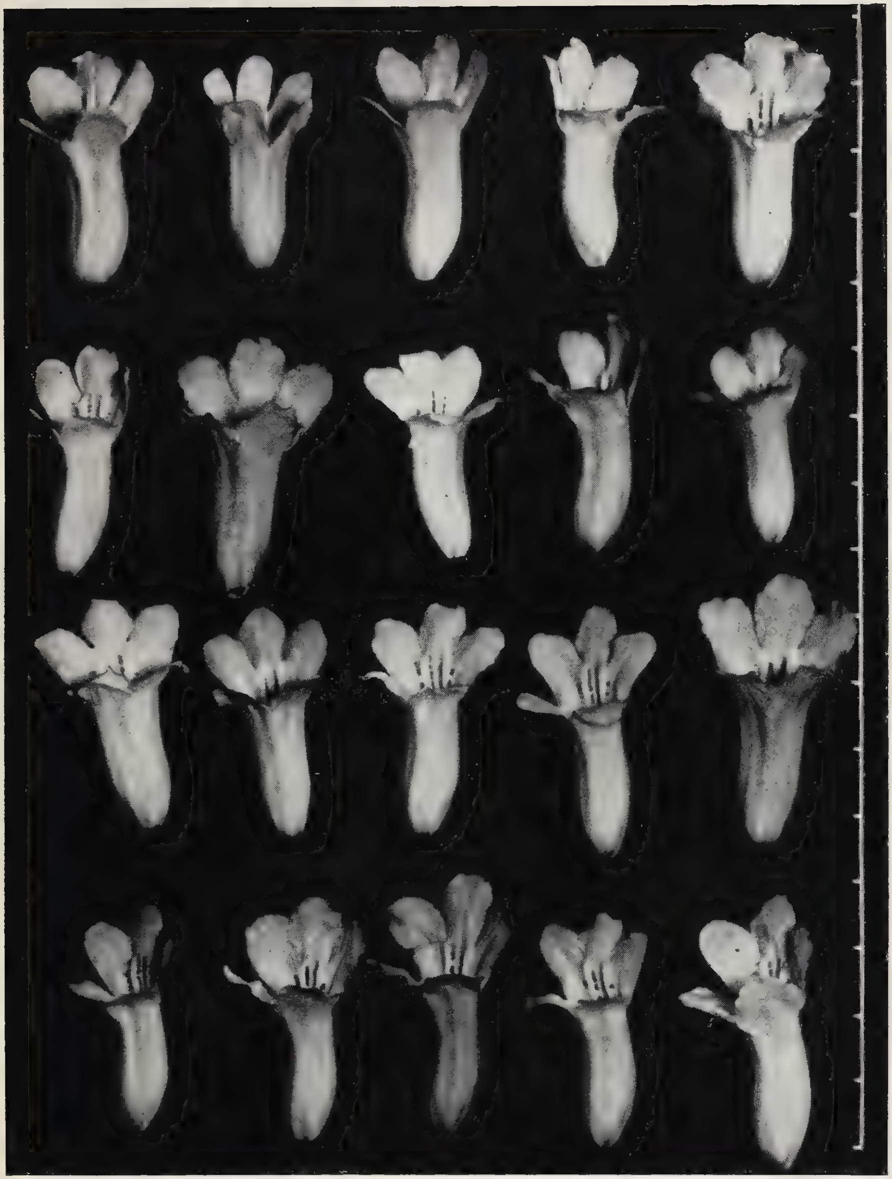


PLATE 3
A sample of 20 corollas from a population of *S. fanniniae* on the farm "The Dargle". Note differences in corolla dimensions, shape of corolla lobes and depth of colouring. Scale in cms.

On the farm "Kilgobbin" *S. fanniniae* grows in profusion along a small stream on the forest margin. *S. gardenii* is common on trees and rocks near the streambank and in the forest. Among the dense stands of *S. fanniniae* are about six clumps of a putative hybrid between the two species (*Hilliard* 848, E, NU).

Putative fanniniae × gardenii

Rosulate, perennial. *Leaves* up to 400 × 88 mm., base cuneate, decurrent on petiole, petiole up to 50 × 8 mm., curved, rooting at base. *Inflorescences* c. 20-flowered, several from apex of petiole. *Peduncle* up to 260 mm., pilose. *Bracts* elliptic, up to 4 × 2 mm., pilose. *Flower* c. 48 mm. long. *Pedicel* c. 9 mm. long, elongating slightly in fruit, pilose with glandular and eglandular hairs. *Calyx* lobes linear, 6 × 1 mm., pilose. *Corolla* tube more or less infundibuliform, almost straight, bluish-violet above, paler below, glandular-pilose, c. 25 mm. long, base 4 mm. in diam., throat 10 mm. in diam.; limb almost straight, upper lobes erect, elliptic, 12 × 11 mm., bluish-violet, almost glabrous outside, paler inside and strongly marked with one solid, and sometimes two broken, deep violet lines, glabrous except for gland-tipped hairs in throat; lower lip c. 18 mm. long, lobes elliptic, 12 × 9 mm., pale bluish-violet, glandular-pilose outside, paler, glabrous inside, marked with deep violet, broken lines; entire floor of the tube pale yellow with irregular violet spots. *Stamens:* filaments inserted about halfway up corolla tube, c. 10 mm. long, curved, thickened apically, sparsely glandular; anther lobes 2 mm. long, white. *Ovary* c. 11 mm. long, pilose, eglandular; style c. 10 mm. long, dorso-ventrally compressed; stigma of two unequal, reniform, papillose lips. *Capsule* 50—60 mm. long.

The plants are morphologically intermediate between *S. fanniniae* and *S. gardenii*, a rosulate species. The habitat favoured is more that of *S. fanniniae*, namely, along the stream-bank, but one young plant was seen on a rock face above the stream, the type of habitat preferred by *S. gardenii*. In habit, however, the putative hybrid resembles *S. gardenii*, and lacks the long spreading petioles of *S. fanniniae*. The leaves resemble those of *S. fanninae* though they are smaller. *S. gardenii* has one or two, occasionally six, flowers per peduncle; *S. fanniniae* has many; the putative hybrid has up to twenty. The shape of the corolla tube is similar to that of *S. fanniniae*, the limb more like that of *S. gardenii*, the upper lobes being marked with a strong median line and the lower with broken lines as in that species, but the floor of the tube is pale yellow spotted violet, reminiscent of *S. fanniniae*.

That the plants breed true from seed is evidenced by clumps of the putative hybrid not only being widely dispersed in the *S. fanniniae* population over several hundred yards of streambank, but also by the occurrence of a seedling

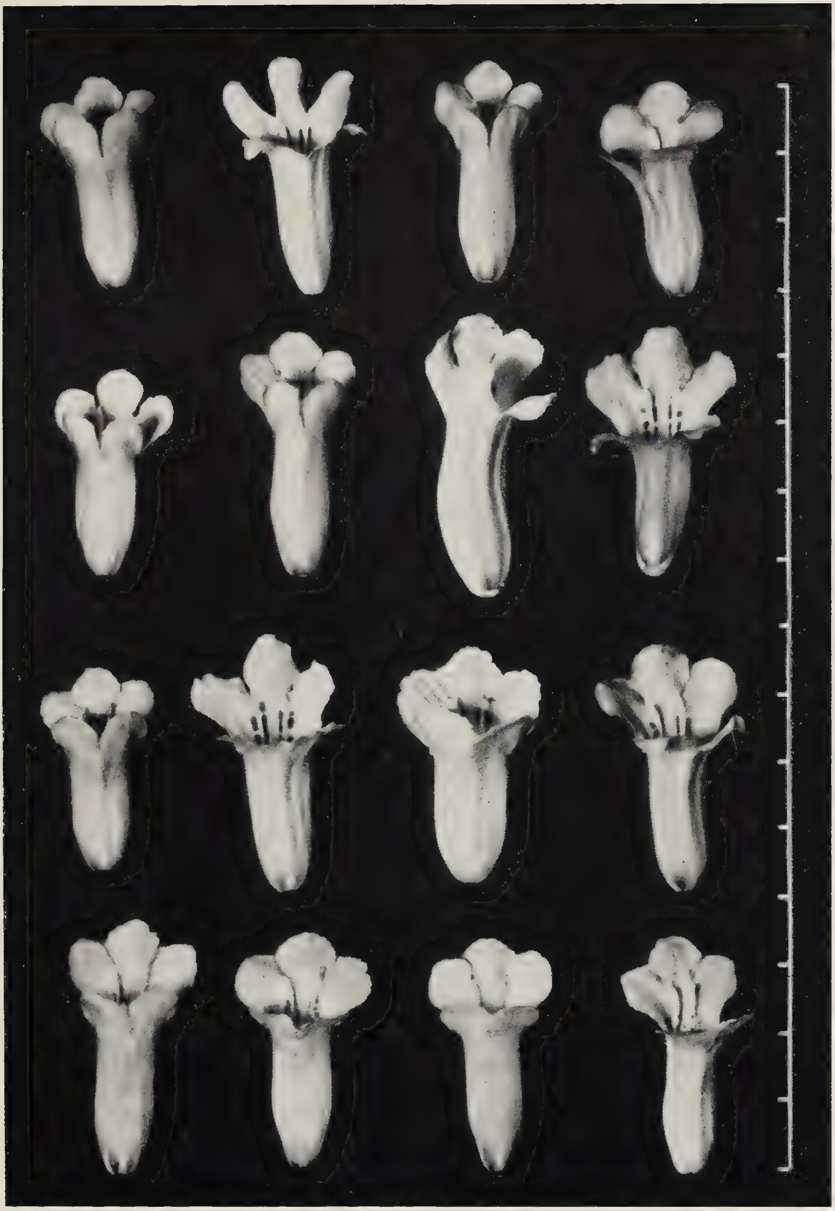


PLATE 4
Corolla variation between populations of *S. fanniniae* (flowers from plants in cultivation). Scale in cms.

plant high on a rock face above the stream. Also, plants raised from seed at the Royal Botanic Garden, Edinburgh, did not differ from the parent.

Although *S. fanniniae* and *S. gardenii* are common associates in Natal Midlands forest, no other intermediates between the two species have been seen. Indeed, the "Kilgobbin" plant is the only example I know of *S. fanniniae* appearing to hybridise naturally with another species. But a sheet of *Wood* 6302 in the British Museum includes one leaf plus a peduncle and one flower that looks remarkably like the "Kilgobbin" plant. It came from Lidgetton, not far from Dargle, the locality of "Kilgobbin". Duplicates of *Wood* 6302 at Kew and Pretoria are *S. fanniniae* only.

2. **S. wilmsii** Engl. in Engl. Jahrbuch 26:363 (1899); C.B. Cl in Dyer, Fl. Cap. 4(2):447 (1904); B. L. Burtt in Kew Bull. 1939:80 and in R.H.S. Dict. Gard. ed. 2, 4:2045 (1956). Transvaal, Lydenburg, Spitzkop, *Wilms* 1025, B, HOLOTYPE (destroyed in 1943), BM, ISOTYPE.

S. muddii C.B. Cl in Dyer, Fl Cap. 4(2):443 (1904); B. L. Burtt in Kew Bull: 1939:80. Transvaal, Umzeila, *Mudd*, K, summit Saddleback range near Barberton, *Galpin* 822, K, NBG, NH, PRE, SYNTYPES.

Monocarpic, possibly sometimes perennial. *Leaf* 1, up to 250 × 180 mm., base cordate to cuneate, upper surface light green, pilose, lower paler, pubescent. *Inflorescences* from base of midrib, many flowers expanded simultaneously. *Peduncle* up to 250 mm. long, green, pilose. *Bracts* lanceolate, up to 7 × 3 mm., green, pilose. *Flower* up to 38 mm. long, honey-scented. *Pedicel* c. 10 mm. long, doubling in length in fruit, green, pilose. *Calyx* lobes linear-lanceolate, 5 × 1 mm., green, pilose. *Corolla* tube straight, white, sometimes suffused palest violet, pilose without, sparsely glandular within, c. 25 mm. long, throat 9 mm. across, floor of tube bisected by a broad yellow streak, spotted violet and extending briefly onto lower lip; upper lobes suberect, elliptic-oblong, 9 × 8 mm.; lower lip porrected, c. 15 mm. long, lobes elliptic-oblong, 8 × 7 mm., all lobes white, pilose outside, glabrous inside. *Stamens:* filaments c. 9 mm. long, twisted, curved, curve dilated, white, sparsely glandular; anther lobes 1·5 mm. long, white; posterior staminode minute, laterals 5 mm. long, white, glandular. *Ovary* 8 mm. long, green, pubescent; style 7 mm. long, white, pubescent in lower half, glabrous above, sharply bent over at tip. *Capsule* 50—90 (6 ± 49) mm. long.

Flowering period: November to March.

TRANSVAAL: Pilgrimsrest dist., Mariepskop, Magalieskop, *Killick and Strey* 2696, PRE, do., Forest Reserve, *Codd* 7875, PRE, do., *v/d/Schÿff* 4504, 4951, PRE, do., *Meeuse* 9999, K, PRE, do., *Burtt* 2928, E, NU; Mauchsberg, *v/d Merwe* 1649, K, PRE; Sabie, Bridal Veil Falls, *Story* 5417, PRE. Barberton dist., 1 ml. Havelock, *Story* 5362, PRE, 3 mls. SW Agnes Mine, *Story* 5451, K, PRE; forest near Agnes Mine, *Britten* 6643, PRE; Barberton, *Strey* 4066, PRE; Lomati Valley, 1500 m., *Thorncroft* 655, NH.

SWAZILAND: Piggs Peak dist., 4 mls. N. Havelock Mine, W end Emlembe Mt., *Reynolds* 3990, PRE; Devil's Bridge, 1680 m., *Compton* 29849, NBG; Kings Forest, c. 1500 m., *Compton* 27841, NBG, PRE, do. *Hilliard* 3101, E, K, NBG, NH, NU. Mbabane dist., "Stroma", *Compton* 25821, K, PRE; "Ukutula", *Compton* 25883, PRE; hills N. Mbabane, *Compton* 28687, NBG.

S. wilmsii is common in the forests of the eastern Transvaal and Swaziland, from Mariepskop to Mbabane. It grows on steep earth or rock banks, and is sometimes epiphytic. The plant is generally solitary-leaved and monocarpic, but it is probable that some plants at least are perennial by virtue of the occasional development of a new leaf from the stump of an old one. *Burtt* 2928 shows dry fruiting peduncles in association with new growth. Two other Mariepskop specimens (*Codd* 7875 and *Meeuse* 9999), in addition to *van der Merwe* 1649 (Mauchsberg), *Compton* 27841 (King's Forest, Swaziland) and *Britten* 6643 (Barberton), have one or two small leaves at the base of the flowering leaf. They may indicate perennation or in some cases merely be seedlings. It is difficult to judge in dried material.

In *S. wilmsii*, both branches of the dichasium are well developed and the flowers stand away from one another, giving a very open inflorescence. The white corolla spotted violet on the floor of the tube is remarkably similar to that of *S. candidus*. *S. candidus* can, however, be distinguished by the two inverted vees at the base of the lower lip, a trivial character, but one that appears to be constant and which can be detected in herbarium material (see *Gerrard* 1979, TCD) collected over a hundred years ago. In addition, the ovary of *S. wilmsii* is eglandular, that of *S. candidus* glandular.

But so close is the overall floral resemblance between these two species that they are diagnosed virtually on habit. *S. wilmsii* is unifoliate and usually monocarpic, *S. candidus* is rosulate and perennial.

In King's forest, near Havelock, Swaziland, four plants intermediate between, apparently, *S. cyaneus* and *S. wilmsii* were seen in an area where a large population of *S. wilmsii* grows in close proximity to an equally large population of *S. cyaneus*. The general likeness of the intermediates was to *S. cyaneus* with its "rosette" of leaves and funnel-shaped flowers, but the corolla tube of the putative hybrids was shorter and less abruptly narrowed to the base and the limb shorter than in typical *S. cyaneus*. In this respect, the corolla resembled that of *S. wilmsii*. Colour of tube and limb, too, resembled that of flowers in the *S. cyaneus* population, but whereas the yellow stripe on the floor of the corrolla tube is never spotted in *S. cyaneus*, that on the floor of the suspected cross was conspicuously spotted deep magenta-violet, which is characteristic of *S. wilmsii* (See *Hilliard* 3100, NU).

3. S. **candidus** O. M. Hilliard in Jnl. S. Afr. Bot. 30(3):112 (1964). Natal, Ngome forest, c. 1070 m., *Hilliard* 863, NU, HOLOTYPE.

S. luteus C.B. Cl. in DC. Monog. Phan. 5:153 (1883) p.p. quoad spec. Gerrardianum and in Dyer, Fl. Cap. 4(2):445 (1904) p.p. quoad spec. Gerrardianum.

S. candidus is known only from Ngome forest and its immediate environs, but its range could probably be extended by field work in this little-visited part of Zululand. It grows epiphytically, or on steep earth banks, spring-lines and streambanks. In wet situations it is commonly associated with *S. fanniniae*.

S. candidus, *S. wilmsii* and *S. fanniniae* form a very interesting trio in view of former emphasis on leaf number in delimiting sections of the subgenus (Fritsch, 1893 and Clarke, 1904), and their close affinity is discussed after the descriptions of the latter two species.

4. **S. davyi** S. Moore in Jnl. Bot. 1905:171. Swaziland, Mbabane, *Burtt Davy* 2836, BM, HOLOTYPE, PRE, ISOTYPE.

Perennial. *Leaves* several, the flowering ones petiolate and often developing one or two peduncle-producing leaves in succession from near apex of main petiole, up to 300 × 160 mm., light green, paler below, base subcordate, margin undulate, both upper and lower surfaces pilose with glandular and eglandular hairs; petiole up to 60 × 10 mm., light green, pilose with glandular and eglandular hairs. *Inflorescences* from apex of petiole and base of midrib, many flowers expanded simultaneously. *Peduncle* up to 140 mm. long, green, glandular-pilose. *Bracts* elliptic, up to 12 × 3 mm., green, glandular-pilose. *Flower* 15—20 mm. long. *Pedicel* 3 mm. elongating to up to 10 mm. long in fruit, green, glandular-pilose. *Calyx* lobes linear, 6 × 1 mm., pale green, glandular-pilose. *Corolla* tube slightly deflexed about the middle, 10—15 mm. long, 3 mm. diam. at base, 3 mm. in throat, slightly narrowed towards middle, white, sometimes with yellow blotch within at point of insertion of filaments, glandular-pilose with occasional acute hairs without, glabrous within; upper lobes sub-orbicular, 3 × 3·5 mm.; lower lip c. 5 mm. long, lobes sub-orbicular, 3 × 4 mm.; all lobes white, glabrous inside, glandular-pilose outside. *Stamens:* filaments 5 mm. long, white, twisted, curved, slightly thickened about the curve, glabrous; anther lobes 1 mm. long, white tinted violet; posterior staminode minute, laterals c. 2 mm. long, white. *Ovary* 4 mm. long, white, glandular-pilose; style 6 mm. long, white, pilose. *Capsule* 11—23 (16 ± 3) mm. long, 2 mm. diam.

Flowering period: January to March.

SWAZILAND: Mbabane dist., hill NE Mbabane, 1340 m., *Compton* 27549, NBG, PRE, 25352, K, PRE; Mbabane, *Story* 5432, PRE; Mbabane, Fonteyn, *Hilliard* 3068, E, K, NU, NH; Mankaiana dist., Mankaiana, *Bayliss* 1803, garden no. 21482, PRE.

S. davyi is known only from Swaziland, where it is common under granite outcrops on the hills around Mbabane. It grows in black, peaty soil, often dripping wet, in the shallow caves and crannies in the rock.

The plants are remarkably viscid. Each consists of a tuft of several sub-erect leaves. A petiole is scarcely noticeable in the small, young leaf, but as each leaf approaches flowering size, it becomes petiolate, The inflorescences, which develop at the apex of the petiole, are thus borne above the basal rosette. A second petiolate, flowering leaf usually develops at the apex of the primary petiole just below the point of origin of the inflorescences. This may in turn produce yet another petiolate, flowering leaf. The flowering axis thus branches sympodially (Plate 2b).

Several flowering axes may develop contemporaneously and each dies away after fruiting, but is replaced by accessory leaves and the plant as a whole is perennial.

The affinity of *S. davyi* is with *S. pusillus*, which it closely resembles but from which it differs in its rather longer and narrower and more viscid leaves, and in its inflorescences which are usually, but not always, more elongate than those of *S. pusillus*. But *S. davyi* is most readily distinguished by its perennial habit, that is, by the production of accessory leaves at the base of the flowering leaf or leaves.

5. **S. pusillus** Harv. ex C.B. Cl in DC. Monog. Phan. 5:149 (1883); C.B. Cl. in Dyer, Fl Cap. 4(2):443 (1904); B. L. Burtt in R.H.S. Dict. Gard. ed. 2, 4:2045 (1956).

Clarke (1883) cited three specimens: *Cooper* 1032 and 947, and *Sanderson* 511. *Cooper* 1032, comprising leaf and fruiting peduncles only, is *S. pusillus*. *Cooper* 947 is a mixture of *S. pusillus* and *S. pentherianus*, to which an annotation by B. L. Burtt draws attention. *Sanderson* 511 is *S. prolixus*.

Clarke (1904) cited in addition *Baur* 728, *Rehmann* 6916, and *Evans* 357. Baur's and Evans's specimens were correctly determined, but *Rehmann* 6916 is *S. pentherianus*.

Clarke's descriptions of *S. pusillus*, based as they are on three distinct species, must be discounted, but the name can be retained since one element can be selected as a satisfactory type. *Cooper* 1032, from the Orange Free State, but without precise locality, K (3 sheets) is therefore nominated LECTOTYPE, BM, ISOLECTOTYPE.

Monocarpic, all parts pilose with glandular and eglandular hairs. *Leaves* 1 or 2, occasionally 3, up to 220 × 160 mm., base subcordate, upper surface light green, lower paler; petiole (hypocotyl) up to 40 mm. long, rooting at base. *Inflorescences* from base of midrib, many flowers expanded simultaneously. *Peduncle* up to 120 mm. long, often much shorter, green. *Bracts* somewhat falcate, up to 20 × 3 mm., green. *Flower* c. 18 mm. long. *Pedicel* 5—10 mm. long, elongating slightly in fruit, green. *Calyx* lobes linear, 5—8 × 1 mm., green. *Corolla* tube slightly curved, c. 10 mm. long, 3 mm. diam., white; upper lobes elliptic, 4 × 3 mm., scarcely divergent; lower lip c. 8 mm. long, lobes elliptic, 5 × 3·5 mm.; all lobes white, glabrous inside, sparsely glandular outside. *Stamens:* filaments 4 mm. long, slightly curved, curve somewhat dilated, white, connective toothed, or pilose with long jointed hairs, or often with a combination of tooth and hairs; anther lobes 1 mm. long, white; posterior staminode minute, laterals 2 mm. long, white. *Ovary* 4 mm. long, white, pubescent with glandular and eglandular hairs; style 5 mm. long, sparsely glandular. *Capsule* 15—25 mm. long, 2 mm. in diam.

Flowering period: November to February.

NATAL: Newcastle dist., Normandien Pass, 1935 m., *Hilliard* 1036, NU; Normandien forest, 1996 m., *Hilliard* 1147, NU; Majuba, 2073 m, *Hilliard* 2269 NU; Utrecht dist., Naauwhoek, *Devenish* 495, PRE; Bergville dist., Natal National Park, Goodoo Bush, *Bayer and McClean* 153, NU, PRE; do., *Oliver* 509, NU; Oliviershoek Pass, *Thode* 4342, 4362, STE; slopes of Mont aux Sources, 21-2400 m., *Flanagan* 2099, NBG, PRE; on way to Tugela Gorge, *Schweickerdt* 796, PRE; Hlolela, farm "The Cavern" near Echo Cave, 1750 m., *Hilliard* 812, E, NU; Cathedral Peak, *Schelpe* 984, NH, NU, do., 1843 m., *Hilliard* 809, NU, do., Gogok Caves, 1707 m., *Germishuizen* 38, PRE; Klip River dist., Van Reenen Pass, 1676 m., *Hilliard* 1148, NU. Estcourt dist., Kamberg, *Smuts* 1069, PRE; Kamberg area, farm "Game Pass". *C. Gordon-Gray* 47, NU; Giants Castle, 2700 m., *Symons* 346, PRE; Underberg dist., Bushmans Nek, 2255 m., *Hilliard* 1003, NU; farm "Selborne", 1800 m., *Hilliard* 999, NU; Underberg, *Dyer* 3250, K, PRE; Sani Valley, *Brooke* 56, BM.

ORANGE FREE STATE: Harrismith dist., Nelson's Kop, 1920 m., *Hilliard* s.n., NU; Harrismith, *Sankey* 217, K; Platberg, c. 2000 m., *Putterill* s.n., (in partim) PRE; Rensberg's Kop, Swinburne, Jacobsz s.n., PRE 29744.

BASUTOLAND: sine loc., *Cooper* 947 in partim, K.

CAPE: Maclear dist., Hopedale, Maclear Mt., legit E.M.Y., *Moss* 18454, J; near Maclear, S.W. of Ugie, farm "Pomona", *Farrington* s.n., PRE 29134;

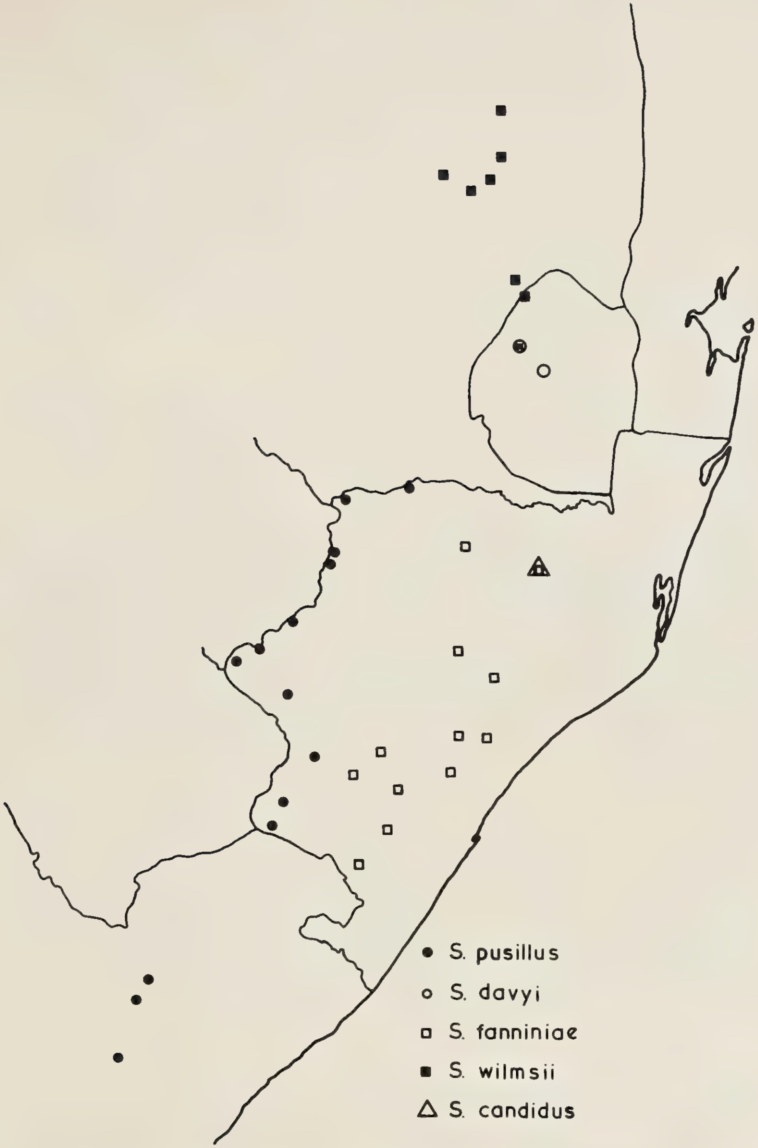


Plate 5.
Distribution of the five species included in the *S. fanniniae* alliance.

Tembuland, nr. Gatberg, *Baur* 728, K; Engcobo dist., c. 20 mls. E. Engcobo, Gulandoda forest, legit. L. F. Gibson, *Hilliard* 1927, NU.

S. pusillus occurs in the Drakensberg area of Natal and neighbouring mountain regions of the Cape, Basutoland, and Orange Free State, usually at altitudes greater than 1650 m. The apparent distributional gap (Plate 5) between the eastern Cape and Natal can be attributed to lack of collecting in that area.

S. pusillus is commonly found in damp, shady crevices of the Cave Sandstone cliffs that are such a prominent feature of Drakensberg scenery. But it also grows on damp rocks and steep banks in kloof forest, where the plants are often larger than those from exposed rock habitats.

The corolla is usually pure white, but Devenish reported some pale mauve specimens on the farm " Naauwhoek" in the Utrecht district of Natal. There is some variation too in the appendages on the connective, which may be toothed; or bearded with long, jointed hairs, a feature not seen in any other South African species; or there may be a combination of both tooth and hairs.

In *S. pusillus*, a second petiolate flowering leaf often develops at the apex of the hypocotyl opposite the primary leaf, and occasionally a third leaf at the apex of the second petiole. The pattern of branching in the flowering axis is therefore sympodial and identical with that of *S. davyi* and of *S. fanniniae*. The plant is upright, and roots only from the base of the primary petiole (hypocotyl), which is generally well developed. There is no development of accessory leaves from the base of the primary petiole, and the plant is monocarpic. (See Plate 2a). So strong is the floral resemblance between *S. pusillus* and *S. davyi* that growth pattern alone is a reliable diagnostic criterion (cf. *S. wilmsii* and *S. candidus*).

ACKNOWLEDGEMENTS

I should like to express my appreciation to the Natal Parks, Game and Fish Preservation Board and to the Departments of Forestry in Natal, the Transvaal, and the Cape for permitting me to collect specimens in their reserves, and in particular I should like to acknowledge the unfailing co-operation and helpfulness of their officers in the field. I am also grateful to the many people who sent me or brought me specimens, and to the farmers of Natal who gave me free access to their properties.

REFERENCES

CLARKE, C. B. 1904: Gesneraceae in Thiselton Dyer's *Fl. Cap.* 4(2):437–447.

FRITSCH, K. 1893–4: Gesneraceae in Engl. and Prantl, *Die Natürlichen Pflanzenfam.* 4(3B):133–144 (1893), 145–185 (1894). (Streptocarpus pp. 150–152).

LAWRENCE, W. J. C. 1958: Studies on Streptocarpus Lindl. 5. Speciation and Gene Systems. *Heredity* 12(3):333–356.

STUDIES ON THE GERMINATION OF SEED OF PROTEACEAE

J. van Staden

(*Department of Botany, University College of the Western Cape, Bellville, South Africa*)

ABSTRACT

Investigations were made of the influence of different treatments on the seed germination of *Protea barbigera*, *P. cynaroides*, *P. eximia*, *P. grandiceps* and *Leucospermum nutans*.

It appears that light has an influence on the germination of proteaceous seed. Seeds of three species, viz., *P. eximia*, *P. grandiceps* and *L. nutans*, germinated best in the dark, while *P. cynaroides* showed the opposite. (The seeds of *P. barbigera* were not treated in the dark.)

Whether germination inhibitors are the cause of dormancy in this family, cannot be decided at present. The highest germination percentages were, however, found when the seeds of the four species were watered with deionised water. This might be an indication of the presence of water soluble inhibitors.

INTRODUCTION

In previously published works (Horn 1962, Thorns 1943, Van Staden and Coetzee 1965, Vogts 1958, 1960 and Werner 1951) the authors have shown that seeds of the South African Proteaceae germinate unsatisfactorily. Vogts (1960) suggested that the dormancy of proteaceous seed is brought about by germination inhibitors, which could be leached out, if the seeds were watered regularly. Horn (1962) on the other hand, did not regard inhibitors as important in the germination of seed of this family. According to him good seed germination may be had with *Protea*, *Serruria* and *Leucospermum* merely by an effective way of sorting the sound from the unsound seed prior to sowing. These conflicting reports have not been proved beyond doubt.

The present investigation deals with the comparative effects of deionised and leached water on the seed germination of five species of the Proteaceae, in light and in the dark.

MATERIAL AND METHODS

Seeds of five species belonging to two genera of the Proteaceae, viz., *Protea* and *Leucospermum*, were examined. Seed of *Protea barbigera* Meisn. was collected in the Klein Swartberg Mountains near Ladismith Cape, that of *P. cynaroides* Linn. near Port Elizabeth, *P. eximia* (Salisb. ex Knight) Fourc (= *P. latifolia* R.Br.) in the Outeniqua Mountains, *P. grandiceps* Tratt. in the Riviersonderend Mountains, and *Leucospermum nutans* R.Br. near Botrivier. Seeds of all species were collected during 1964. All the seeds used were carefully sorted and only those being plump and able to resist some pressure were sown.

On the 2nd February, 1965, seeds of *P. barbigera* were sown in clay pots (4″). Every pot was heavily coated with bitumastic paint and filled with a fairly uniform, acid-washed sand.

Twenty seeds were sown in each of 24 pots at a depth of approximately one and a half times the diameter of a seed. These were then divided into three groups of eight each. The pots of group one were watered once in four days with 100 ml. of deionised water and those of group two with 100 ml. of leached water (for the duration of the experiment the seeds were watered with the same water, made up to the original volume with deionised water for every watering) and the third group with 100 ml. of a gibberellic acid solution (10 ppm). The pots were kept in the laboratory under light conditions for 92 days, and the number of seeds that germinated, was recorded every four days.

Twenty seeds each of *P. cynaroides*, *P. eximia*, *P. grandiceps* and *L. nutans* were sown on the 28th April, 1965, in each of 16 pots, in the same way as those of *P. barbigera*. The 16 pots were divided into four groups of four each, and were treated, once every six days, with deionised and leached water, under both light and dark conditions. The seed of the proteas was allowed to germinate for 96 days, and that of the *Leucospermum* for 150 days. During this period the temperature in the laboratory was measured with a maximum–minimum thermometer. It varied between 12·2 and 24·4°C for the period shown in Fig. 4. For the period not shown in the figure it never exceeded the above extremes. The number of seeds that germinated, was recorded every six days.

At the end of the experiments the remaining seeds were examined to determine whether they were fertile when sown. By using the total of seeds germinated and those not germinated but with full-grown embryos, the mean germination percentage for each treatment was determined.

RESULTS AND DISCUSSION

Seed of *P. cynaroides* and *P. eximia* started germinating after 24 days, followed by *P. barbigera*, *P. grandiceps* and *L. nutans* which germinated after

TABLE 1

The effect of different treatments on the seed germination of P. cynaroides, P. eximia, P. grandiceps, and *L. nutans.* (All results are expressed as a percentage of the fertile seeds sown.)

	Treatments			
	Seeds watered with deionised water		Seeds watered with leached water	
	light	dark	light	dark
P. cynaroides:				
Mean germination*	31·25	20·00	22·50	18·75
Highest recorded germination ..	45·00	35·00	35·25	30·25
Lowest recorded germination ..	25·00	15·50	10·00	00·00
P. eximia:				
Mean germination*	38·75	50·00	41·25	40·00
Highest recorded germination ..	60·00	64·50	55·00	50·25
Lowest recorded germination ..	15·00	30·00	29·25	20·00
P. grandiceps:				
Mean germination*	60·00	61·25	57·50	58·50
Highest recorded germination ..	75·00	80·00	70·00	84·75
Lowest recorded germination ..	45·00	40·00	50·25	45·00
L. nutans:				
Mean germination*	5·00	6·25	2·50	5·00
Highest recorded germination ..	15·00	10·00	5·00	10·00
Lowest recorded germination ..	00·00	5·00	0·25	00·00

* Each value represents the mean of 4 replicates.

28, 30 and 36 days respectively (Figs. 1 to 5). The best germination was recorded for *P. grandiceps* (61·25%) followed by *P. eximia* (50·00%), *P. barbigera* (35·82%), *P. cynaroides* (31·25%) and *L. nutans* (6·25%) (Tables 1 to 2). Germination for *P. eximia* and *P. grandiceps* stopped after 60 days and for

TABLE 2

The effect of different treatments on the seed germination of P. barbigera. (All results are expressed as a percentage of the fertile seeds sown).

	Treatments		
	Seeds watered with deionised water	Seeds watered with leached water	Seeds watered with gibberellic acid*
	light	light	light
Mean germination**	30·00	35·82	15·82
Highest recorded germination ..	55·00	55·00	35·82
Lowest recorded germination ..	15·00	10·00	5·00

* Solution of 10 ppm. ** Each value represents the mean of 8 replicates.

P. cynaroides six days later. The seeds of *P. barbigera* and *L. nutans* germinated during the whole experimental period.

As can be seen from Table 1 the seeds of *P. grandiceps*, *P. eximia* and *L. nutans* showed the highest germination percentages in the dark. Only the seeds of *P. cynaroides* germinated well in the light. In 1962 Horn found that seeds of *Protea* germinated under daylight conditions as well as in darkness. He concluded that light is of no importance in the germination of these seeds. The

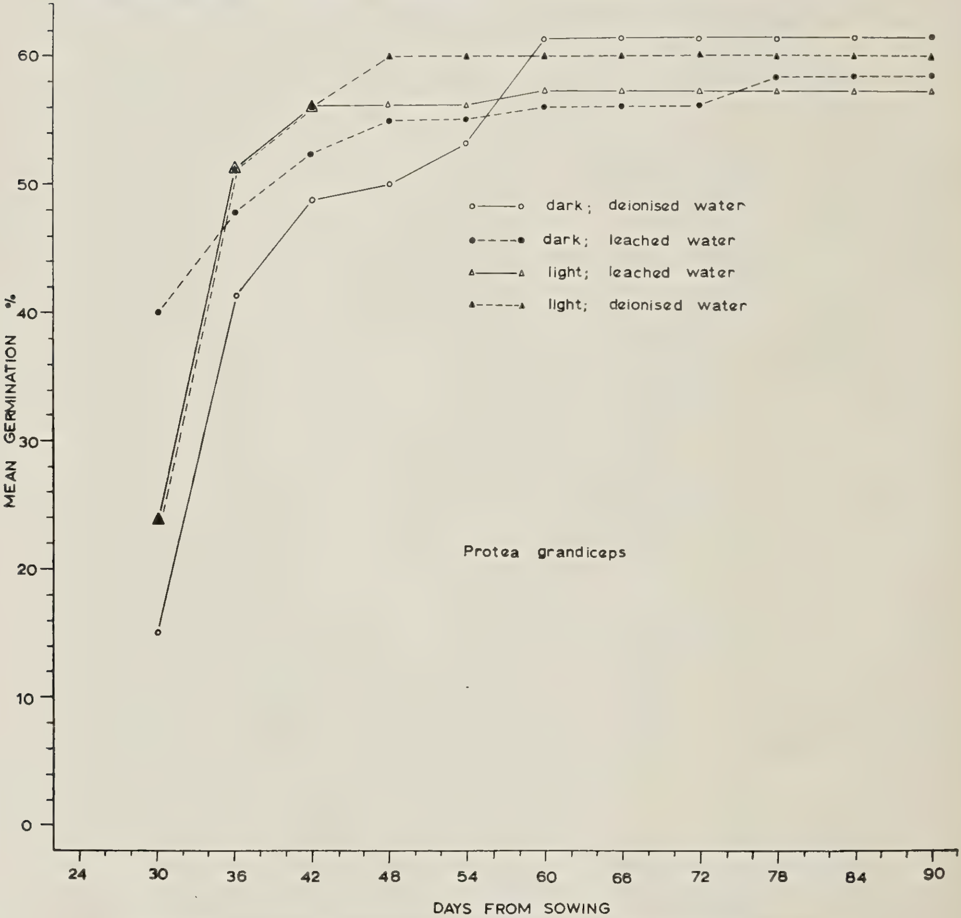


FIG. 1.—Germination rates of seed of *Protea grandiceps* with different treatments.

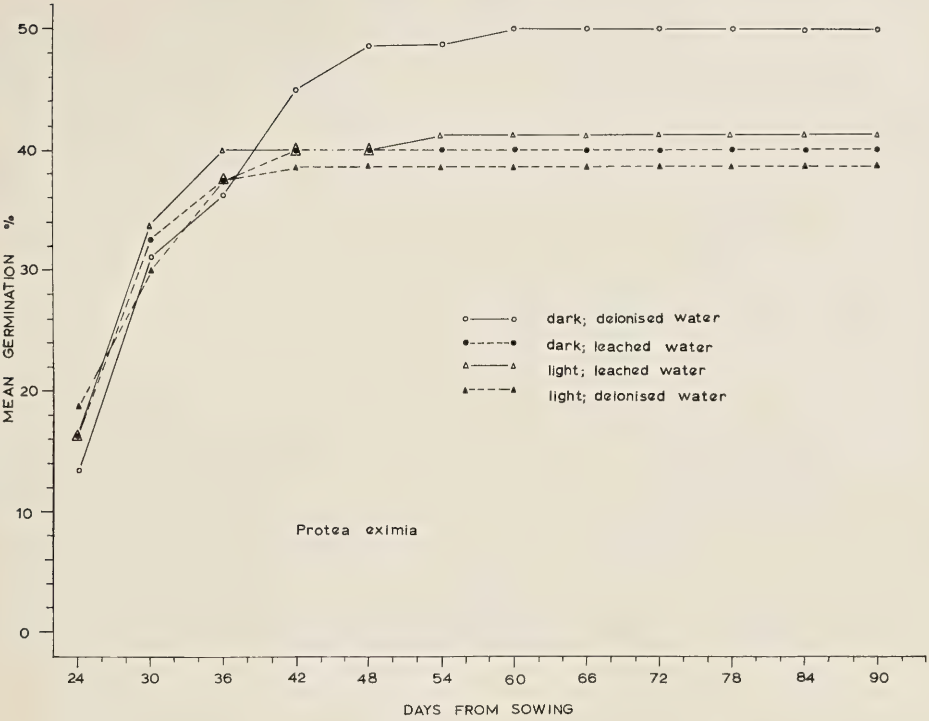


FIG. 2.—Germination rates of seed of *Protea eximia* with different treatments.

present results indicate that light might possibly play a role in the germination of the four species investigated. One must, however, be careful when interpreting the results because of the wide variation found in each treatment. Further experiments are necessary to decide the matter.

Some differences of opinion exist regarding the reasons for the poor germination of proteaceous seed. Vogts (1960) ascribed it to germination inhibitors, and Horn (1962) to ineffective means of separating fertile from infertile seed.

The question of germination inhibitors, if not well diluted, keeping the seeds dormant (Vogts 1960) cannot be decided at present. It is, however, interesting that the highest germination percentages were obtained with seeds watered with deionised water (Table 1). This seems to suggest that water soluble

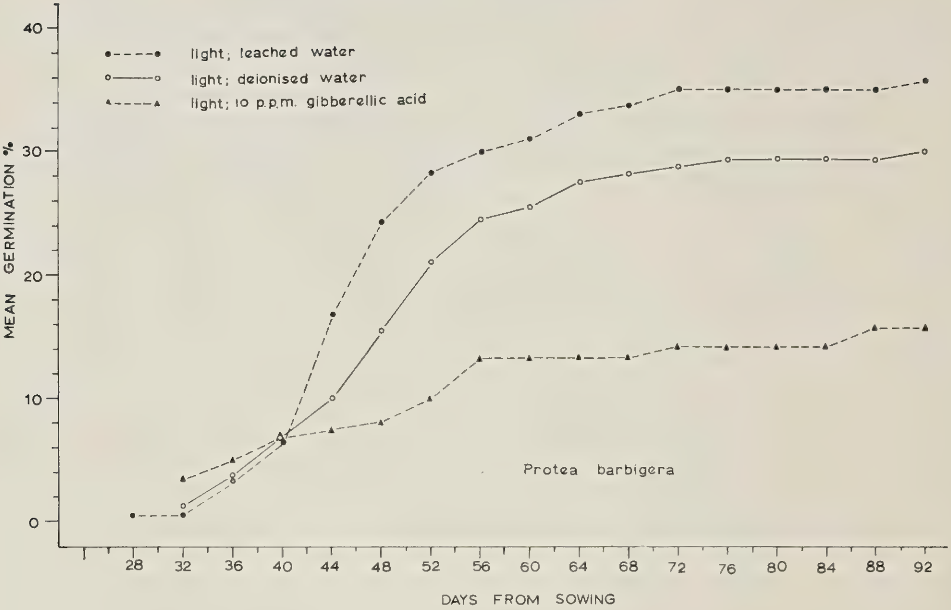


FIG. 3.—Germination rates of seed of *Protea barbigera* with different treatments.

inhibitors were present in the leached water. No tests were carried out to determine whether this was the case. The situation is somewhat different with *P. barbigera* where the best germination occured with leached water (Table 2). Gibberellic acid had only a retarding effect on the germination of this species.

Horn (1962) was of the opinion that the main cause for the poor germination in Proteaceae can be ascribed to ineffective seed-screening methods. In the present experiments and in Horn's (1962) own studies good sorting still gave poor germination percentages. Furthermore, in the present investigations 90% of the seed of *P. barbigera* which did not germinate had full-grown embryos. In the case of *P. cynaroides*, *P. eximia*, *P. grandiceps* and *L. nutans* the corresponding figures were 95%, 91%, 89% and 76% respectively. These results indicate that the poor germination obtained cannot be ascribed only to ineffective seed sorting and that dormancy must be considered as an important factor.

To solve the different questions further experiments are necessary.

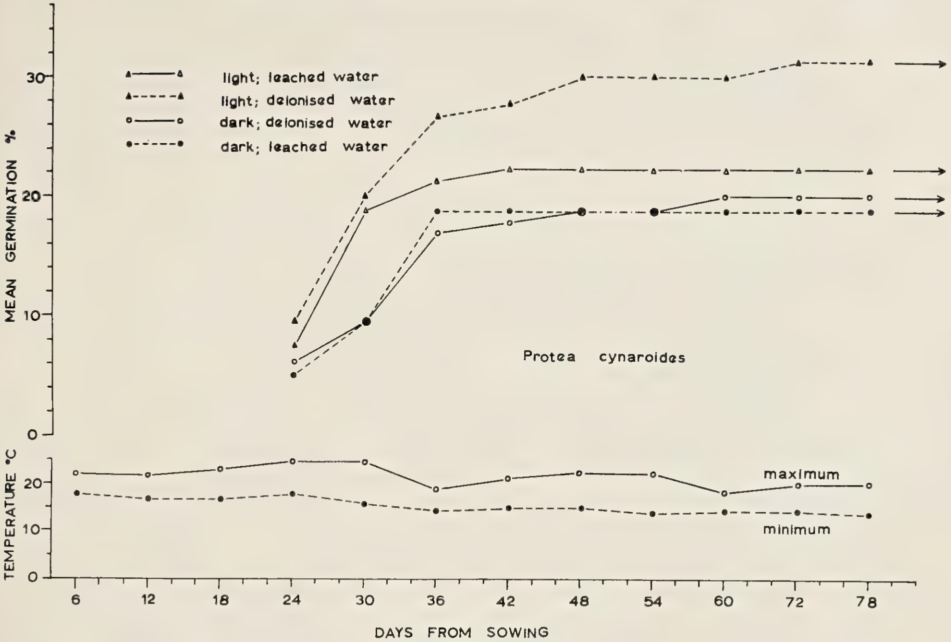


FIG. 4.—Germination rates of seed of *Protea cynaroides* with different treatments. Maximum and minimum temperatures under which the seeds germinated, for 78 days, are also shown.

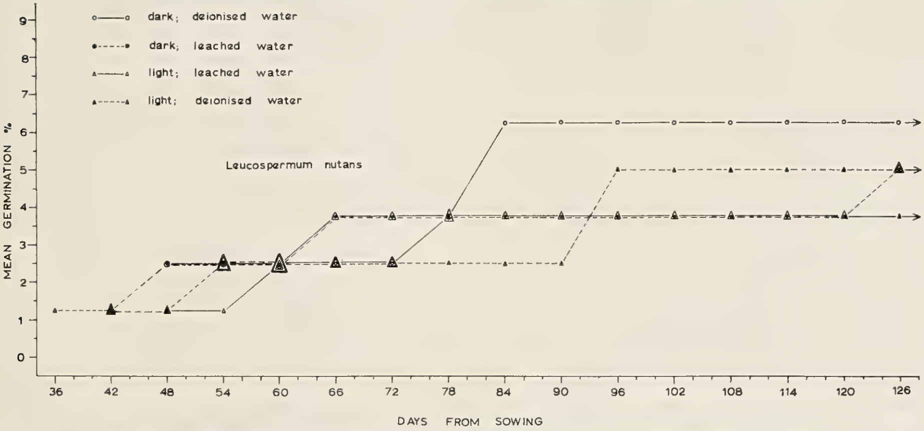


FIG. 5.—Germination rates of seed of *Leucospermum nutans* with different treatments.

ACKNOWLEDGEMENTS

The author wishes to thank Prof. P. G. Jordaan and Mr. E. G. H. Oliver for reading the manuscript critically. I am also indebted to Mrs. M. M. Vogts who kindly supplied the seeds used in experiments with *P. cynaroides*, *P. eximia*, *P. grandiceps* and *L. nutans*.

REFERENCES

HORN, W. (1962): Breeding research on South African plants: II. Fertility of Proteaceae *J. S. Afr. Bot.* **28** : 259–268.

THORNS, F. W. (1943): South African Proteaceae in Cultivation. *J. Bot. Soc. S. Afr.* **29** : 9–12.

VAN STADEN, J., EN COETZEE, F. M. C. (1965): Die moontlikheid van stremstowwe in die sade van *Protea cynaroides* L. *Annale van die Universiteitskollege Wes-Kaapland Jaargang* **II** : 19–23.

VOGTS, M. M. (1958): *Proteas: know them and grow them.* Afrikaanse Pers Boekhandel, Johannesburg.

VOGTS, M. M. (1960): The South African Proteaceae: The need for more research. *S. Afr. J. Sci.* **56** : 297–305.

WERNER, H. F. (1951): South African Proteaceae and their cultivation. *J. Bot. Soc. S. Afr.* **37** : 14–17.

JOURNAL
OF
SOUTH AFRICAN BOTANY
VOL. 32

Published: 14th October, 1966

STAPELIEAE FROM SOUTH TROPICAL AFRICA, III.

L. C. Leach & D. C. H. Plowes

Recently, whilst searching through the bibliography of the adjacent floral areas for references to the *Stapelieae* of the Flora Zambesiaca area, there came to light an excellent drawing of *Caralluma schweinfurthii* Berger (Robyns, Flore Sperm. Parc Nat. Albert 2: Pl. XI).

This figure depicted a plant which appeared to be identical in all respects with *C. piaranthoides* Obermeyer. Subsequently, examination of material of *C. schweinfurthii*, kindly sent on loan to Pretoria from Brussels, and of the type material of *C. piaranthoides*, together with the published descriptions and figures of both species, confirmed this view. It is consequently now possible to publish the following notes with the synonymy and distribution of this wide, spread species.

Caralluma schweinfurthii Berger, Stapelieen und Kleinien: 103 (1910).—White & Sloane, Stapelieae **1** : 274 (1937).—Robyns, Flore Sperm. Parc Nat-Albert **2** : 104 (1947).—Jacobsen, Handb. Succ. Pl. **1** : 255 (1960). Type: Congo Sous-district de la plaine de la Rutshuru, *Stuhlmann* 2208 (B, holotype †); Vitshumbi, *De Witte* 1023 (BR, neotype).

Caralluma piaranthoides Obermeyer, in Fl. Pl. S. Afr. **15**: t.599 (1935).—White & Sloane, tom. cit.: 285, 1184 et fig. 1232 (1937).—Luckhoff, Stap. S. Afr.: 32 et 36 (1952).—Jacobsen, tom. cit.: 252 (1960). Type: S. Rhodesia, Wankie Distr., *Levy* 8444 (PRE).

Congo.—Sous-district de la plaine de la Rutshuru, 9. v. 1891, *Stuhlmann* 2208 (B†); Vitshumbi, fl. Oct. 1933, *De Witte* 1023 (BR); Kabare, fl. Aug. 1914, *Bequaert* 5381 (BR); Katanda, fr. Sept. 1937, *Lebrun* 7669 (BR); Rwindi, st. Oct.

1937, *Lebrun* 8056 (BR); Kanyasembe, fl. Dec. 1937, *Lebrun* 9231 (BR). Sous-district de la plaine de la Semliki: Kasonero, st. July 1914, *Bequaert* 5033 (BR).

RWANDA.—Bugesera, Kibugabuga, fr. 28. ix. 1953, *Liben* 639 (SRGH).

S. RHODESIA.—Wankie Distr.: cult. Transv. Mus., fl. March 1935, *Levy* 8444 (PRE); Lukosi Riv., cult. Nelspruit, fl. Feb./March 1965, *Leach* 12123 (B; BR; G; K; PRE; SRGH). Kariba Distr., Chirundu, fl. 16. iii. 1961 *Drummond & Rutherford-Smith* 6919 (SRGH). Binga Distr., Lusulu, fl. 27. ii. 1965, *Bingham* 1413 (SRGH).

TANZANIA.—Central Province, Great Ruaha Gorge, cult. Greendale, S. Rhodesia, fl. Feb. 1961, *Leach & Brunton* 10139 (PRE); Kondoa-Irangi, cult. Amani, fl. 5. iii. 1936, *Greenway* 4595 (EA, photo.); Iringa Escarp. cult. Langata, fl. Apr. 1962, *Bayliss*, s.n. (PROB).

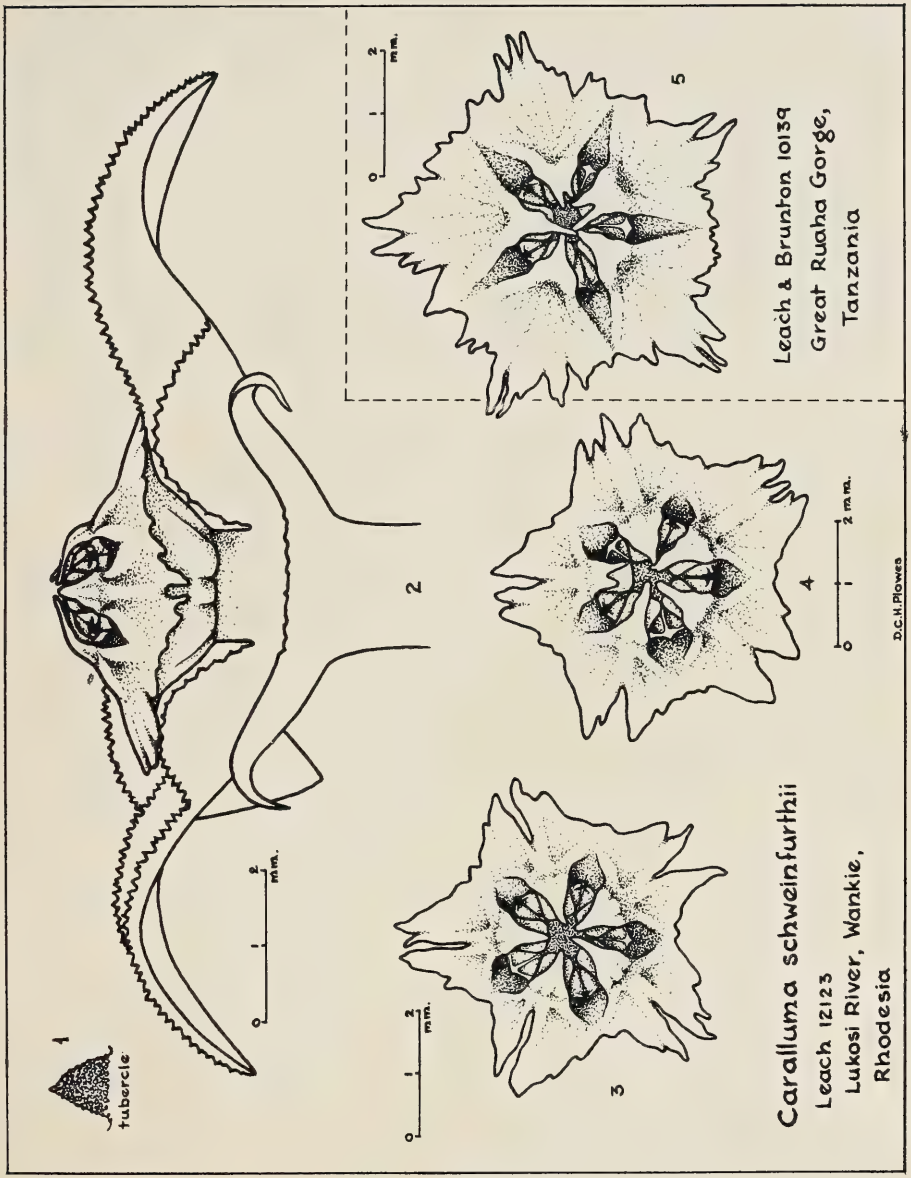
UGANDA.—Fort Portal—Kwanza road, *Joy Bally* s.n., fl. Dec. 1939, in *Bally* S29 (PRE, photo; PROB); Fort Portal—Mbarara road, *Eggeling* E5502 (PRE; PROB); Ankole, Ruizi Riv., fl. 4. ii. 1951, *Jarrett* 441 (PROB).

ZAMBIA.—Kalomo Distr., Machili, fl. 10. ii. 1961, *Fanshawe* 6234 (NDO; SRGH).

The sterile and fruiting specimens from Congo and Rwanda are not, of course, absolutely positively identifiable but have been included here as the stems and habit are considered to match those of *C. schweinfurthii* rather than of *Stapelia semota* N. E. Br., the only other Stapeliad having somewhat similar stems which is known to occur in the area.

It seems probable that the species occurs more frequently than the records would suggest. It is known to be quite common in some parts of the Zambesi valley, particularly in the Wankie District, but the comparative insignificance of the plants, which are usually concealed by low herbs and grasses, the fact that the above-ground portions usually die down during the dry season (cf. *Duvalia polita* N. E. Br. which is also present in the Wankie Distr. growing under identical conditions) and its somewhat difficult cultivation, have all, no doubt, contributed towards the relatively infrequent gatherings and have possibly exaggerated the widely scattered nature of its distribution.

Despite the wide range of distribution there seems to be little variation of any significance; the corolla colour ranges from yellow to brownish and the markings have been variously described as, wine-red, red, terra-cotta, and purple. The distinctive, finely toothed outer corona varies somewhat in outline, being sometimes 10-pointed (Obermeyer *l.c.*), often 5-pointed, or more rarely, more or less circular. The 5-pointed coronas are formed by the adjacent sides of the deeply indented lobes being closely contiguous or sometimes fused together, in such cases the resulting points (apparent lobes) are opposite the corolla lobes.


1
tubercle
0 1 2 mm.
2
3
0 1 2 mm.
4
0 1 2 mm.
5
0 1 2 mm.
Caralluma schweinfurthii
Leach 12123
Lukosi River, Wankie,
Rhodesia
Leach & Brunton 10139
Great Ruaha Gorge,
Tanzania
D.C.H.Plowes

Caralluma schweinfurthii, Great Ruaha Gorge, Central Tanzania, flowering in cultivation at Greendale, S. Rhodesia, *Leach* and *Brunton* 10139. Photo: L. C. Le

The plants from Gt. Ruaha Gorge, Central Tanzania have, in cultivation, developed stems which are much more robust than any others seen, either cultivated or wild, the flowers are also slightly larger than the average. However, in view of the more or less normal size of the stems of these plants when collected and the fact that *Greenway* 4595, from Kondoa-Irangi, shews some even larger flowers in conjunction with stems of normal proportions, it is not considered that the giant Great Ruaha plants should be accorded any taxonomic recognition.

While *C. schweinfurthii* does not appear to have any particularly close affinity with other members of the genus there are, as is so often the case with the *Stapelieae*, some remarkable similarities to be observed in several taxa belonging to other genera, such as *Piaranthus*, *Pectinaria* and *Stultitia* and which it is hoped to discuss in a later paper, meanwhile it is the present authors' opinion that this species fits best into and should therefore be retained in *Caralluma*.

The type of *C. schweinfurthii* has apparently been destroyed and no paratypes are known to exist but comparison of the specimens from the vicinity of the presumed type locality with Berger's description and figure of the corona (*l.c.*) leaves no doubt regarding the identity of the species. Of the three flowering specimens from the Rutshuru plain, *G. de Witte* 1023 (BR) seems most likely to have been collected at the locality closest to that of Stuhlmann's 2208, as Emin Pasha's party camped at 'Vichumbi' on May 10, 1891 (G. Schweitzer, The Life & Work of Emin Pasha, **2**: 206) and has therefore been selected as the neotype.

There does remain, however, a very slight element of doubt regarding the type locality; in Berger's original description this was given as: near Nswiwa, Itande. It seems certain that the locality which Berger had in mind and which was subsequently accepted by White & Sloane (*l.c.*), was that situated at approximately 8° S, 28° 45′ E, that is, some 20–25 miles NE of Lake Mweru (Moero) and about halfway between southwestern Lake Tanganyika and the Luapula River.

Robyns (*l.c.*), however, points out that Stuhlmann's itinerary passed very much further to the north; the dates and localities given in Petermann's Geogr. Mitt. and in G. Schweitzer's 'The Life & Work of Emin Pasha' (1898) confirm this and show that the route followed by Emin Pasha's Expedition of 1890–92 passed close to the SW shore of Lake Edward before turning north to Lake Albert. The party was in the vicinity of the SW corner of Lake Edward between the 2nd and 15th May 1891, probably in the Rutshuru plain, as suggested by Robyns (*l.c.*), it follows therefore, that Stuhlmann's gathering 2208 dated May 9, 1891 must have been made in this area. Whilst the possibility exists that labels may have become mixed or even that the specimen may have been collected by some other collector at Berger's locality and erroneously credited to Stuhlmann and although, in the absence of the type or of any of the original labels or records, it is not possible for the locality to be fixed with certainty, it does seem to be a reasonably safe assumption that this was in the Rutshuru Plain just to the south-west of Lake Edward. It is in this area that several subsequent gatherings have been made, while none are recorded from Berger's locality.

Acknowledgments

The authors wish to express their sincere thanks to:—

Mr. P. R. O. Bally for the loan of material from his private herbarium, herein referred to by the abbreviation (PROB), for much informative and helpful correspondence regarding the type locality of *C. schweinfurthii* and a map shewing Berger's locality.

Dr. L. E. Codd, Chief, Botanical Research Institute, Pretoria, and his staff, for the facilities of the Herbarium, for their ever-ready assistance and to Mr. H. R. Tölken for translations from Berger's "Stapelieen und Kleinien".

The Director, Royal Botanic Gardens, Kew, for much of the information concerning Emin Pasha's journeys and the relevant bibliography.

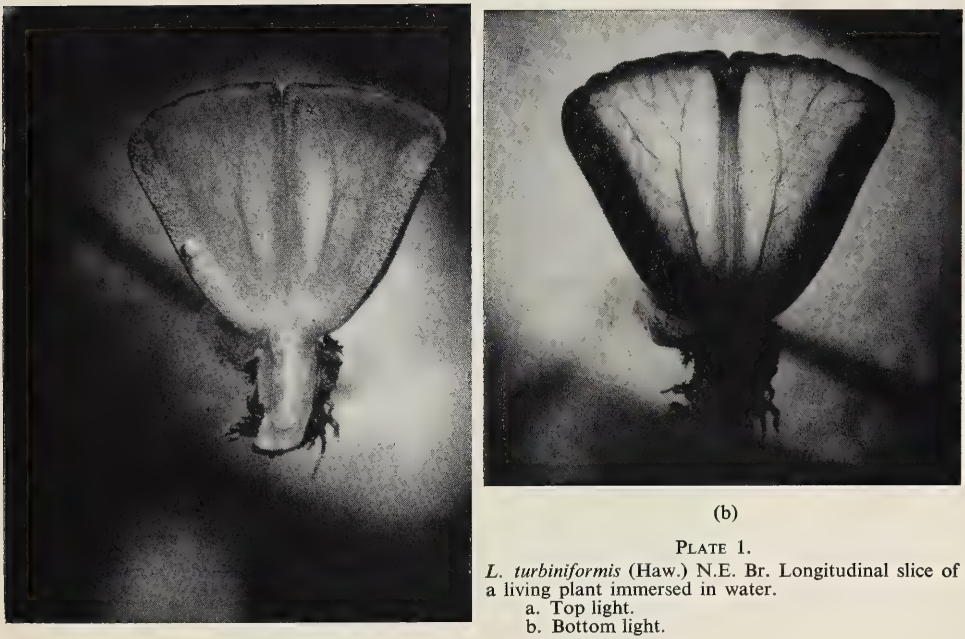
The Directors of: Jardin Botanique de l'Etat, Bruxelles (BR), the East African Herbarium, Nairobi, (EA) and the Herbarium, Forestry Dept., Ndola NDO), for the loan of material.

Dr. H. Wild and the staff of the Government Herbarium, Salisbury, for the facilities of the Herbarium and a great deal of assistance generally.

SOME NOTES ON THE INTERNAL ANATOMY OF *LITHOPS:* I

CHESTER B. DUGDALE
(*Fairleigh Dickinson University, Rutherford, New Jersey, U.S.A.*)

Many studies have been made that were concerned primarily with the taxonomy of the genus *Lithops*, and many workers, both professional botanists and laymen, have contributed to our knowledge of the coloration patterns and the markings on the surfaces of these plants. A search of the literature, however, reveals that very little information has been assembled concerning their internal cellular anatomy. It is the intent of this paper to present some of this anatomical detail.



(a)

(b)

PLATE 1.
L. turbiniformis (Haw.) N.E. Br. Longitudinal slice of a living plant immersed in water.
a. Top light.
b. Bottom light.

Plate 1 shows a longitudinal slice of a 2-year old *Lithops turbiniformis* that was sectioned with a razor blade. It was photographed under water to prevent dessication. A prominent band of chlorenchyma cells can be seen lying beneath the abaxial epidermis and a narrower band is located on either side of the cleft. The central core of each leaf consists mainly of water-storage parenchyma cells and strands of xylem vessels. At the point where the mature leaves are attached to the root-stem complex, the faint beginnings of the growth of a new pair of leaves can be discerned. The arrangement of the vascular bundles is better seen in the bottom-lighted specimen shown in plate 1 (b). The lateral dark bands are the chlorenchyma cells as is also the dark upper central area.

Plate 2 is a photograph of an unidentified *Lithops* that had been preserved, dehydrated, and cleared in xylol. In handling the specimen, the new leaves were accidentally detached from the root-stem complex so that only the old leaves remained. A button of tissue was revealed which appears to be the stem of the plant since the strands of xylem that enter the leaves are arising from it. However, a study of microtomed sections of this region reveals no evidence of cellular

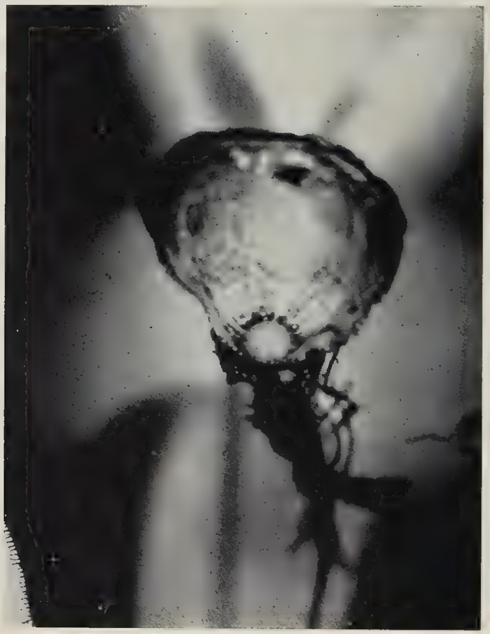


Plate 2.
Lithops sp. Dissected plant showing button-like remnant of stem.

differentiation into distinct root and stem tissues as they are typically seen in dicotyledonous plants.

Plate 3 shows the results of an experiment concerned with the movement of water from the older leaves of the plant into the newer ones. One of the leaves of a 1-year-old seedling of *L. helmutii*, in soil, was injected via a hypodermic needle with a drop of aniline blue dye. An hour afterward the plant was uprooted, washed free of soil, longitudinally sectioned with a razor blade, and immersed in 1% hydrochloric acid. It will be noted that the dye has travelled down the xylem from the injection site into the root-stem complex, and then ascended into both of the new leaves and the old leaf on the opposite side. Both this plate and plate 1 (b) indicate a dichotomous type of venation in the *Lithops* leaf.

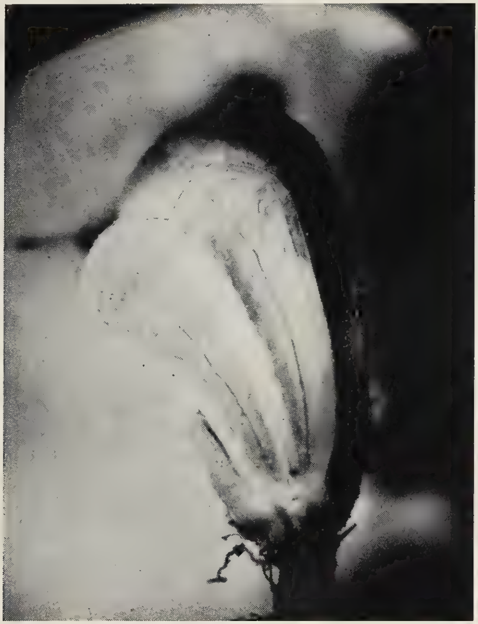


PLATE 3.
L. helmutii L. Bol. Living plant injected with aniline blue and showing dichotomous veining in new leaves.

Plate 4 shows a plant that was similarly injected, but was also preserved, dehydrated, and cleared. Aniline blue followed by 1% HCI was the only stain of several tried that was retained by the plant during the necessary processing; in all other techniques the stains were removed by the alcohol used in the dehydration of the tissue. Although this passage of the dye through the plant does not rigorously prove that cell fluids also pass from the old leaves into the new growth, it does show that a route for such a flow exists.

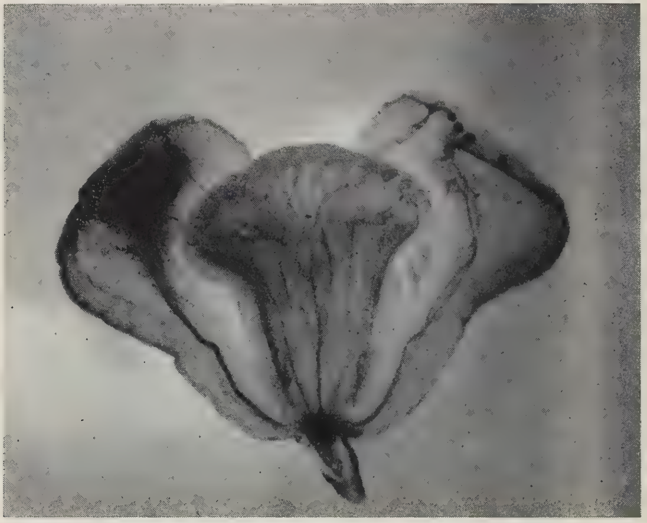


PLATE 4.
Lithops sp. Preserved plant showing injection site in old leaf (upper left) and route of dye as it passed into new leaves and old leaf of opposite side.

When this work was started some two years ago, it was decided that two plants of each species or variety would be cut into $\frac{1}{4}$-inch slices and preserved. One plant was to be cut transversely and the other longitudinally. As the preservation proceeded, however, the excessive shrinkage of the tissue in the FAA-type preservative made it necessary to devise a formula especially suited to succulent material. A solution consisting of phosphomolybdic acid combined with small amounts of formalin and acetic acid was found to give satisfactory, shrinkage-free, preservation of the gross specimen as well as good cytological detail in the microtomed sections, and it has been used consistently since.

As one proceeds with the dehydration and clearing of many species of *Lithops* his attention is drawn to the reddish-coloured bodies that are to be found scattered among the parenchyma cells just below the epidermis of the

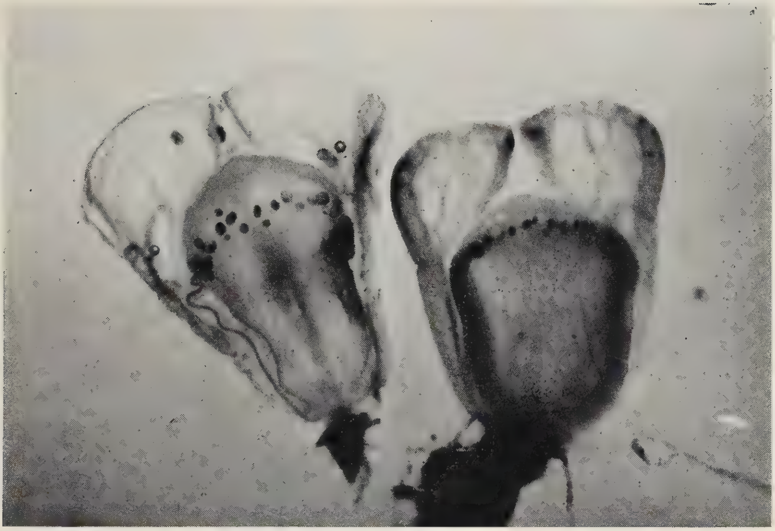
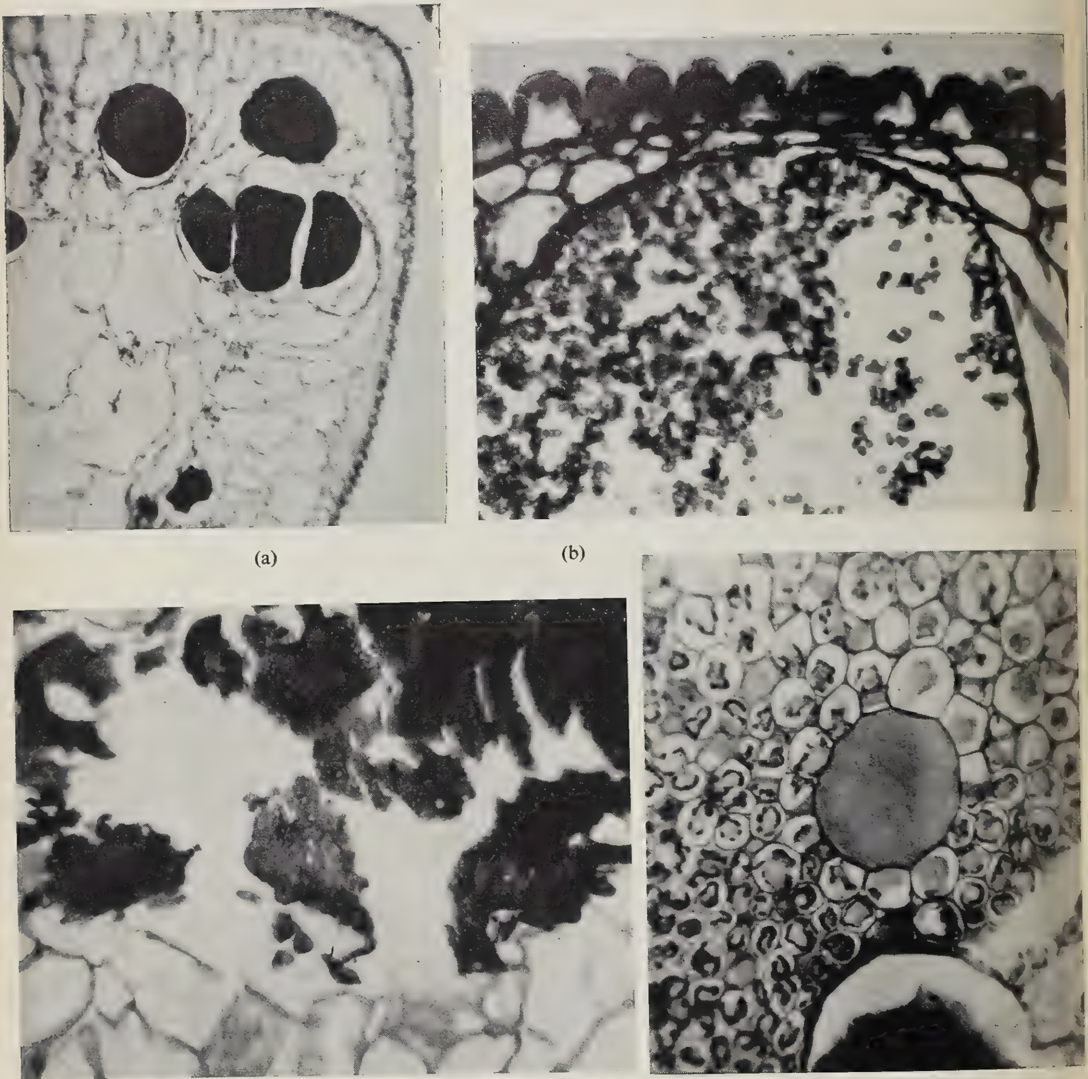


PLATE 5.
L. localis (N.E. Br.) Schw. Tanniniferous idioblasts in new leaves.

top surface. Sometimes these bodies, which are known as tanniniferous idioblasts, are also beneath the ab- and adaxial surfaces. See plate 4 upper right side, and plate 5 where idioblasts appear to be limited to new leaves only. These bodies are normally invisible in the fresh *Lithops* leaf because there they are colourless. However, the same colour that develops during dehydration of the plant in alcohol may also develop during the natural dehydration of old shrivelling leaves, and then the idioblasts can be seen as one peers through the epidermis. They are also always readily apparent in the dried-up epidermal covering found on *L. lesliei* just before the new leaves break through. Similar tannin-containing sacs are common to those other *Mesembryanthema* that I have checked. On the other hand, certain specific *Lithops* plants that I have processed have failed to show any idioblasts, so the possibility exists that these bodies may come and go in response to some unidentified metabolic cycle.

The study of the tanniniferous idioblasts is interesting from at least two points of view. Examination of sectioned material with the microscope reveals at least four distinct types of idioblast construction. See plate 6. Type a. appears to be quite glass-like. It is so hard that it usually fragments under the impact of the microtome knife, but the fragments have no discernible in-



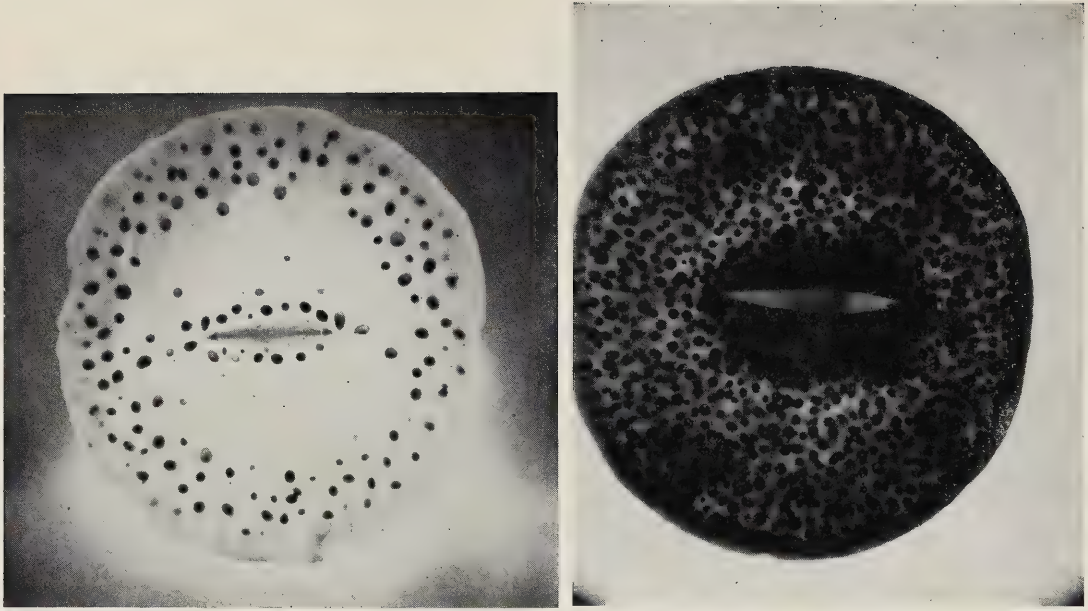
(a) (b)

(c) (d)

PLATE 6.

Tanniniferous idioblasts.

a. *L. aucampiae* L. Bol. Amorphous-type idioblasts (× 100).
b. *L. glaudinae* de Boer Plastid-type idioblast (× 430).
c. *L. ruschiorum* (Dint. & Schw.) N.E. Br. Vacuolated-type idioblast (× 430).
d. *L. verruculosa* var. *inae* (Nel) de Boer & Boom Finegrain-type idioblast (× 100).



(a) (b)

Plate 7.
Spatial relationships of tanniniferous idioblasts.
a. *L. aucampiae* L. Bol.
b. *L. lesliei* (N.E. Br.) N.E. Br.

ternal structure. Type b. is composed of small plastid-like bodies that are attached to each other in irregular groupings. Also this type of idioblast very often shows a denser, nucleus-like region as may be seen in plate 5. Type c. resembles type a. except that the glassy mass is vacuolated like styrifoam or the gas bubbles in lava rock. Type d. has a very fine-grained texture. To what extent these four types may have any species specificity or, indeed, to what extent they may be artifacts of dehydration is difficult to ascertain, since they cannot be dissected out of the fresh leaf for comparison. However, in sectioned material I have found up to three of the four types in one plant at one time. Further investigation will have to be made to determine to what extent the types of idioblasts are real and constant and hence of some possible taxonomic significance.

The second aspect of these bodies that arouses interest concerns their size, number, and placement within the plant. If the upper $\frac{1}{4}$-inch of a young *L. aucampiae* is removed from the plant and is preserved, dehydrated, and cleared, it takes on the appearance seen in plate 7 (a), and this appearance is constant for all *L. aucampiae* of similar age and cultural conditions that I have treated. Likewise, *L. lesliei*, seen in plate 7 (b), has a configuration of idioblasts that is distinctive and constant also. Hence, in this regard it may likewise be true that a study of large numbers of specimens from all the species and varieties, and raised under differing cultural conditions, may produce information of taxonomic significance.

ACKNOWLEDGEMENTS

This work has, in part, been made possible by a Fairleigh Dickinson University Research Grant and by funds received from the Cactus and Succulent Society of New Jersey and the New York Cactus and Succulent Society. Also a gift of seeds from the National Botanic Gardens, Kirstenbosch, is gratefully acknowledged.

REFERENCES

METCALFE, C. R. and Chalk, L. (1950): *Anatomy of the Dicotyledons*. **1.** Oxford University Press, London.

EFFECTS OF BORON, MANGANESE, COPPER AND ZINC UPON THE GROWTH OF *SETARIA SPHACELATA*

J. A. DE BRUYN* AND WAYNE J. McILRATH†

(*Department of Botany, University of Chicago, U.S.A.*)

ABSTRACT

Plants of *Setaria sphacelata* (Schum.) Stapf and Hubbard, Kazungula ecotype, were grown for eight months in sand culture with different levels (0 to 200 ppm) of the micronutrient elements B, Mn, Cu and Zn. Their growth and micronutrient contents were determined.

No definite symptoms of a B deficiency were observed in the main experiment; increased tillering, accompanied by cessation of stem elongation and death of growing points were observed in an accompanying minus-B control in water culture and in a subsequent subculture without B in sand. Symptoms of B toxicity (necrotic spots along leaf margins) and reduced growth were observed with 5 ppm or more of B.

Symptoms of a Mn deficiency—consisting of chlorosis and death of younger leaves and growing points, and eventually death of whole tillers—developed in plants receiving 0·05 ppm or less of Mn. Mn toxicity symptoms (small necrotic spots on older leaves and stems) developed with 100 and 200 ppm of Mn, but growth was not affected.

No definite symptoms of deficiency of Cu or Zn were observed in sand or water culture; growth and development were not affected at low levels of these elements. Symptoms of Cu toxicity developed in plants receiving one ppm or more of Cu; general chlorosis, severely reduced growth and flowering, and often death were noted, particularly at the higher levels of Cu.

Zn toxicity, as indicated by leaf necrosis and severely reduced growth and flowering, developed with 100 and 200 ppm of Zn.

It was concluded that *S. sphacelata* has a definite requirement for Mn and probably also for B. Requirements for Cu and Zn are probably quite low, and contamination apparently was not completely eliminated during this investigation.

INTRODUCTION

Although the essentiality of micronutrient elements in plant nutrition has long been established, the responses of many species to these elements have not yet been determined. Native and cultivated grasses in particular have received relatively little attention. This applies even more specifically to African grasses.

Previous research has shown several micronutrients to be indispensable for

---

* Present address: Department of Botany, University of Stellenbosch, Stellenbosch, South Africa.

† Present address: The Graduate School, Northern Illinois University, De Kalb, Illinois 60115, U.S.A.

normal growth and development of certain grass species (Sommer, 1927; Schropp and Arendz, 1940; Williams, 1951) under greenhouse conditions. Their effects upon grasses and pasture plants under field conditions have also been studied, mainly in terms of forage yield (Hodges, Killinger and Carrigan, 1945) and chemical composition (Beeson, Gray and Adams, 1947; Weinmann, 1951).

Apart from their effects on vegetative growth, micronutrients have also been found essential for flowering and seed production of a number of species (Gizzard and Matthews, 1942; Reed, 1942; Hasler and Maurizio, 1947; Wood and Sibly, 1950). This might be a secondary effect, however, since severe deficiencies usually result in cessation of growth, or even death, before the flowering stage.

Nutritional disorders in plants are usually indicated by the development of characteristic symptoms of deficiency or toxicity. Colour atlases of such symptoms in many fruit, vegetable and cereal crops have been compiled (Bear and Coleman, 1949; Wallace, 1951), but information regarding their occurrence in native grasses is relatively meagre.

In addition to visual symptoms, the chemical composition of plants provides en index of their nutritional status; it has often provided the first clue to the atiology of nutritional disorders (Goodall and Gregory, 1947). Both whole plants and specific tissues have been used for this purpose (Goodall and Gregory, 1947).

This report deals with the response of the perennial African grass, *Setaria sphacelata* (Schum.) Stapf and Hubbard (golden millet) to different levels of boron, manganese, copper and zinc. In addition to observations on plant growth and development, symptoms of any nutritional disorders were noted in terms of the supply as well as the internal levels of the elements involved.

MATERIAL AND METHODS

Seeds of *Setaria sphacelata* (Kazungula ecotype, strain P1191) were planted in acid-washed quartz sand in one-litre glazed earthenware crocks. The seedlings were supplied with deionised water for four weeks, and subsequently with Hoagland and Arnon's (1950) No. 2 macronutrient solution, consisting of 0·006M KNO_3, 0·004 M $Ca(NO_3)_2 \cdot 4H_2O$, 0·002 M $MgSO_4 \cdot 7H_2O$ and 0·001 M $(NH_4)_2HPO_4$, buffered at pH 5·5 with H_2SO_4. After two weeks, the plants also received a micronutrient supplement, containing basically 0·5 ppm B, 0·5 ppm Mn, 0·05 ppm Zn, 0·02 ppm Cu and 0·01 ppm Mo. Four series of treatments, in each of which one of the elements boron, manganese, copper or zinc was varied, were initiated at this time. Each series was subdivided into 12 treatment levels, ranging from 0 to 200 ppm, with five plants per treatment.

The plants (one per pot) were arranged in a randomised-block pattern.

Each container was flushed three times weekly with 400 ml of the appropriate nutrient solution, and with 200 ml deionised water containing five ppm ferric tartrate on other days. As the plants grew older, nutrients and water were supplied at more frequent intervals.

For comparative purposes, two plants of each series were also grown in water culture in the absence of the respective elements. One-litre Pyrex beakers were used for the minus Mn, Cu and Zn cultures, and soda-glass quart jars for the minus B culture. Nutrient solution and water were added on alternate days and the solutions were changed weekly. These plants were not analysed for micronutrients.

Nutrient solutions for the boron series were stored in soda-glass containers; Pyrex-glass containers were used for the manganese, copper and zinc series.

For the boron series, reagent-grade chemicals were used without further purification. In the other series stock solutions of the major nutrients were purified according to the method of Steinberg (1935) as modified by Stout and Arnon (1939). Reagent-grade micronutrient salts were used without further purification.

The plants were grown in a greenhouse in Chicago, Illinois, for altogether eight months (from March until November) under conditions of natural day-length. At harvest the shoots were cut off about two cm. above the level of the sand. After removal of the inflorescences (ears), dry weights of the above-ground parts (shoots) were determined after drying at 80°C in a forced-draught oven for 72 hours. Because it was impractical to measure individual tillers, the tillers over and under 150 cm. in length (measured from the point of attachment to the ligule of the youngest leaf) were counted. Tillers over 150 cm. were termed long tillers. The inflorescences were measured, cleaned and their seed production determined.

At the time of harvest, one plant from each series receiving no boron, copper or zinc respectively was left to tiller from the root stock. These cultures were maintained on their respective nutrient solutions until the following spring (April), when each plant was broken up into individual tillers. Five of these were planted in individual pots and given the same minus micronutrient treatment as the original plant, while two tillers from each series were supplied with complete nutrient solutions to serve as controls. All these plants were harvested after four months. Apart from observations on their general development, they were not used for growth or chemical analyses.

For chemical analysis the plant material was ground in a Wiley mill to pass a sixty-mesh screen and dried at 100°C. Boron was determined according to the quinalizarin method (Berger and Truog, 1944), manganese by the periodate method (Cook, 1941), copper according to the carbamate method (Eden and Green, 1940) and zinc by extraction with dithizone (Cowling and Miller, 1941). Colour comparisons were made with a Klett-Summerson photoelectric colorimeter, using the following filters: boron—Corning No. 2412; manganese and zinc—Klett No. 54; and copper—Klett No. 44. All analyses were expressed on an oven-dry basis.

Statistical analyses of the results were carried out according to established methods (Snedecor, 1956).

RESULTS AND DISCUSSION

Visual Symptoms of Nutritional Disturbances:

No definite symptoms of boron deficiency were observed in the main sand-culture experiment. In the accompanying water-culture control without boron as well as in the second minus-boron sand culture, some symptoms of deficiency did develop. The growing points of some tillers of each plant died and elongation of stems and leaf sheaths ceased, resulting in a cluster of leaves at the end of each tiller. These tillers died without flowering. Where ears developed, they failed to emerge completely. The final result was a relatively large number of short tillers. Morris (1931) also observed increased tillering in spring wheat in the absence of boron.

Symptoms of manganese deficiency appeared in plants receiving 0·05 ppm Mn or less. They were most severe in plants receiving no Mn, and appeared first in older tillers shortly before flowering. An interveinal chlorosis developed in the centre of the terminal leaf. This area later became necrotic. Necrosis progressed until the whole leaf as well as the growing point of the stem were dead. Eventually the complete tiller died. In some instances inflorescences developed, but failed to emerge completely before dying. Manganese deficiency symptoms of a similar nature have been observed in *Phleum pratense* (Williams, 1951).

No definite symptoms of copper or zinc deficiency were observed at any time in any of the sand or water cultures.

Symptoms of boron toxicity developed as slight necrotic spots along the margins of older leaves of plants receiving five ppm boron. These spots increased in size as the supply of boron was increased. In addition, the plants receiving 100 and 200 ppm B grew poorly; they had thin stems and were often chlorotic. Some plants receiving 200 ppm B died; none of them flowered.

Symptoms probably caused by manganese toxicity developed only in plants supplied with 100 and 200 ppm Mn. They consisted of small, fairly regular necrotic spots on older leaves and the lower internodes of old tillers; young leaves and tillers appeared quite normal.

Setaria sphacelata appeared to be highly susceptible to copper toxicity. Plants receiving one ppm or more of Cu became chlorotic and their development was retarded. Some of the plants supplied with 5 or 10 ppm of Cu died after a few weeks, those receiving 100 ppm became severely chlorotic and died within two weeks, and application of 200 ppm Cu resulted in the death of all plants after three or four days.

Symptoms of zinc toxicity developed only in plants receiving 100 and 200 ppm of Zn. In addition to severely limited growth, small necrotic spots developed along the midribs of young leaves; large necrotic areas occurred on older leaves. Blackening of lower internodes occurred in plants receiving 200 ppm Zn. Some plants at both these levels of Zn eventually died.

General Developmental Effects:

Emergence of inflorescences and flowering commenced about three months after planting the seeds and continued sporadically among the various series after that. At harvest time only about two-thirds of the plants not definitely inhibited by nutrient treatment had flowered. The lack of floral initiation was not correlated with any particular nutrient treatment, for some plants in most treatments failed to flower. The reason for this failure is not clear.

In addition to total inhibition of flowering several abnormalities in floral development were observed, viz., abortive ears (which consisted mainly of a large cluster of leaves attached to a short, flowerless "spike") and a type of vegetative apomixis (in which vegetative bulbils or plantlets replaced the normal flowers). The latter condition has been noted in a number of grasses, e.g., *Poa*, *Bromus* and *Panicum* spp. (Warmke, 1952). These abnormalities were not related to nutrient treatment, and occurred along with normal ears on the same plants.

During the course of the experiment, attempts were made to determine the effects of nutrient treatments in the substrate upon pollen viability. For this purpose pollen was collected in the morning soon after anthesis and germinated in hanging-drop cultures consisting of 15 per cent sucrose and one ppm B (as boric acid). Because some of the plants did not flower, the results were incomplete. In addition, the temperature in the greenhouse increased very rapidly after sunrise (i.e., at the time the pollen was shed), with the result that the pollen germinated and grew very poorly. Even so, the available results did not indicate any relation between nutrient treatment and pollen viability.

At harvest time, observations as to ear length, seed production per plant, average seed production per ear, and seed production per unit of ear length were made. Again, these results were incomplete because many plants failed to flower. Insofar as could be determined, however, no particular trend or consistency was shown with regard to the effects of any micronutrient element upon any of the abovementioned aspects. The detailed data were regarded as insufficient for inclusion in this report, although the effects of the different treatments upon seed production per plant have been included in the tables.

Effects upon Growth and Chemical Composition:

Boron (Table 1).—In general, the concentration of boron in the shoots was not affected by applications of B up to 0·1 ppm, and only slightly by further increases to 0·5 and 1·0 ppm. Additional increases in the amount of B supplied resulted in significant increases in the B content of the shoots. Total dry weight of the shoots was not affected by B levels up to one ppm, but further increases in the application of B generally resulted in reduced dry weight. The largest number of tillers was obtained with 0·001 ppm B in the medium; 100 and 200 ppm of B resulted in significant decreases in tiller production as compared to the other treatments.

TABLE 1.

Effects of Boron Supply upon Boron Content, Growth, Flowering and Seed Production

Boron Supply ppm	B Content of Shoots mg/Kg Dry Wt	Dry Wt of Shoots g	No. of Tillers per Plant	Per cent Tillers over 150 cm	Per cent Flowering Tillers	No. of Seeds per Plant
0·0	13 ± 2	98·6	57·4	26·7	5·9	28·8
0·001	11 ± 1	96·1	64·4	16·1	4·3	25·6
0·005	13 ± 2	97·3	41·4	40·1	2·0	7·8
0·01	15 ± 1	99·8	48·0	35·5	9·9	40·0
0·05	13 ± 1	96·9	44·8	24·8	2·5	0·8
0·1	15 ± 1	96·1	43·8	36·2	6·3	2·8
0·5	19 ± 2	106·8	45·6	42·5	20·2	13·6
1·0	21 ± 3	103·2	41·2	41·8	17·2	176·8
5·0	69 ± 9	88·1	40·6	32·4	4·9	7·6
10·0	95 ± 10	83·7	37·2	37·2	6·2	19·8
100	998 ± 158	24·3	22·0	31·9	1·4	0
200	1,266 ± 440	2·3	5·4	8·1	0	0
L.S.D. (P = 0·05)		17·9	18·4	16·6	12·2	—
(P = 0·01)		23·9	24·6	22·2	16·4	—

If the percentage of tillers over 150 cm is taken as a measure of tiller length, this aspect of growth was little affected by boron. Significant reductions in the percentage of long tillers were obtained only with 0·001 and 200 ppm of B, which probably corresponded to mild deficiency and toxicity conditions, respectively.

The highest percentages of flowering tillers were obtained with 0·5 and 1·0 ppm of B; above and below these levels flowering was considerably reduced.

With the exception of the 0·5 ppm level of B, some plants of all the treatments failed to flower.

Seed production was extremely variable and showed no consistent relation to treatments, but by far the largest number of seeds were produced by the plants supplied with 1·0 ppm of B. No seeds were produced at the two highest levels of B.

The lack of definite deficiency symptoms, together with the variability of the results (as indicated by the relatively high L.S.D. values) make definite conclusions regarding the effects of boron rather difficult. If one considers the increased tillering obtained in water culture and in the second sand culture in the absence of boron, it seems that a certain degree of boron deficiency might have developed in the plants receiving 0·001 ppm of B. Their internal concentration of B (11 mg per Kg of dry weight) was also the lowest. It seems possible that symptoms of a deficiency of B might develop when the internal concentration of B in *S. sphacelata* should fall below 10 ppm. The optimal level of B application—considering the dry weight of the shoots and the percentage of flowering tillers—appears to be in the vicinity of 0·5 to 1·0 ppm, with an internal concentration of about 20 mg B per Kg of dry material.

Manganese (Table 2).—Applications of Mn up to 0·1 ppm had no effect upon the concentration of Mn in the shoots, but further increases in Mn supply resulted in substantial increases in Mn content. The effects of Mn deficiency are reflected in the dry weights of the shoots, which were significantly reduced at

TABLE 2.

Effects of Manganese Supply upon Manganese Content, Growth, Flowering and Seed Production

Manganese Supply ppm	Mn Content of shoots mg/Kg Dry Wt	Dry Wt of Shoots g	No. of Tillers per Plant	Per cent Tillers over 150 cm	Per cent Flowering Tillers	No. of Seeds per Plant
0·0	10 ± 1	27·4	47·0	5·2	0·0	0·0
0·001	10 ± 0	29·4	42·0	7·2	1·2	5·0
0·005	10 ± 2	44·5	54·8	3·0	3·6	3·4
0·01	8 ± 1	53·4	47·4	7·5	3·8	3·8
0·05	10 ± 0	88·0	58·6	23·4	6·8	17·2
0·1	12 ± 2	97·3	47·0	22·2	17·4	42·4
0·5	36 ± 3	117·0	49·4	31·8	18·3	44·0
1·0	77 ± 7	109·1	48·0	35·5	17·9	62·4
5·0	316 ± 43	128·9	42·6	35·5	12·7	3·8
10·0	515 ± 25	106·7	48·2	42·7	8·1	18·0
100	3,230 ± 249	114·1	50·8	43·6	22·4	94·6
200	3,414 ± 96	81·2	38·8	39·8	10·1	31·0
L.S.D. (P = 0·05)		17·7	18·7	12·0	17·9	—
(P = 0·01)		23·6	25·0	16·0	23·9	—

Mn levels of 0·1 ppm and below. Since these plants developed varying degrees of Mn deficiency symptoms, it seems that such symptoms develop in plants with an internal Mn content of about 10 ppm or less. In general, the best growth was obtained with 5·0 ppm of Mn, and an internal Mn concentration of about 300 mg per Kg dry weight.

S. sphacelata appears to be remarkably tolerant to high levels of Mn. At the 100 ppm level of Mn, the tissues contained more than 3 g of Mn per Kg dry weight, or approximately 360 mg Mn per plant, without growth being affected. The fact that 200 ppm of Mn were supra-optimal is reflected in the reduced dry weight of the shoots.

Although Mn had a pronounced effect upon dry weight, tiller formation was not significantly affected. In comparison to Mn levels of one ppm or above, however, the percentage of long tillers was reduced in plants receiving 0·05 and 0·1 ppm of Mn, and even more so at the lower levels of Mn. This reflects the premature dying of tillers at sub-optimal levels of Mn. Some degree of remobilisation of Mn from older to younger tillers appears to have occurred.

Although flowering (i.e., the percentage of flowering tillers) at levels of 0 to 0·05 ppm of Mn was considerably reduced in comparison to that at 0·1 to 100 ppm, most of these differences were not statistically significant, because of the variation in flowering within each treatment. On the average, only three out of five plants in each treatment flowered; only at the 100 ppm level of Mn did all the plants flower. Seed production, although highly variable, was much lower with 0 to 0·05 ppm of Mn than at most of the levels of Mn above 0·05 ppm.

Copper (Table 3).—The concentration of copper in the shoots was not significantly affected by increases in Cu applications up to 0·5 ppm, but higher levels of Cu resulted in considerable increases in Cu content. The dry weight of the shoots, number of tillers per plant and percentage of long tillers, although varying considerably, were not significantly affected by Cu applications up to 0·5 ppm (and an internal concentration of 8 to 16 mg Cu per Kg dry weight). In the presence of 1·0 ppm of Cu, dry weight and tiller length were somewhat reduced, whereas total tiller production was not affected. These growth effects were associated with an internal Cu concentration of 31 ppm. This level of Cu in the tissues was probably slightly supra-optimal. Further increases in the level of applied copper resulted in significant reductions in all aspects of growth, which were associated with the development of toxicity symptoms of various degrees of severity.

The percentage of flowering tillers remained fairly constant at Cu levels up to 0·05 ppm, but decreased sharply when 0·1 ppm of Cu was applied. All the plants receiving 0·01 and 0·05 ppm of Cu flowered; below these levels, 80%

TABLE 3.

Effects of Copper Supply upon Copper Content, Growth, Flowering and Seed Production

Copper Supply ppm	Cu Content of Shoots mg/Kg Dry Wt	Dry Wt of Shoots g	No. of Tillers per Plant	Per cent Tillers over 150 cm	Per cent Flowering Tillers	No. of Seeds per Plant
0·0	8 ± 2	92·7	37·0	30·8	24·3	56·0
0·001	8 ± 1	105·9	40·8	38·0	16·2	32·2
0·005	8 ± 1	99·7	36·0	42·4	18·9	15·6
0·01	9 ± 1	111·0	40·6	40·2	19·2	23·4
0·05	10 ± 1	109·5	40·0	37·9	19·5	54·8
0·1	16 ± 4	93·5	46·6	28·1	10·5	58·8
0·5	15 ± 3	103·5	48·4	31·7	11·6	101·2
1·0	31 ± 5	81·5	51·0	23·8	5·9	5·4
5·0	103 ± 32	11·89	17·8	5·2	0·6	0·2
10·0	339 ± 102	1·32	4·2	0	4·0	0·2
100	14,888 ± 2175	0·02	1·0	0	0	0
200	25,549 ± 3288	0·03	1·0	0	0	0
L.S.D. (P = 0·05)		21·3	16·0	15·8	18·1	—
(P = 0·01)		28·4	21·4	21·1	24·2	—

of the plants flowered. Above 0·05 ppm of Cu, the percentage of plants flowering decreased progressively as the application of Cu was increased.

Best seed production was obtained with 0·5 ppm of Cu in the medium; practically no seeds were produced where 5 ppm or more of Cu had been applied.

The results indicate that *S. sphacelata* has a relatively low requirement for copper, with good growth, flowering and seed production at a copper level of only 8 mg per Kg of dry material. It is difficult to single out an optimal level of copper, however. Of the four micronutrient elements tested, the plants appear to be most sensitive (in respect of growth as well as reproduction) to copper, in that applications of 1·0 ppm or more resulted in significant decreases in growth.

Zinc (Table 4).—For some unknown reason the concentration of Zn in plants receiving 0·001 and 0·005 ppm of Zn was lower than in plants not receiving any Zn. Otherwise, the Zn content of the tissues was not appreciably affected by applications of Zn up to 0·5 ppm. Above that level, the Zn content increased markedly as the application was increased.

Although the growth of the plants varied somewhat, applications of Zn from 0 to 10 ppm—and internal Zn concentrations from 9 to about 380 mg per Kg dry weight—had no significant effect upon the dry weight of the shoots or (with one or two exceptions) upon the number of tillers per plant. Both dry weight and number of tillers were considerably reduced in plants receiving 100 ppm or more of Zn, however. Tiller length was rather variable and did not show

TABLE 4.

Effects of Zinc Supply upon Zinc Content, Growth, Flowering and Seed Production

Zinc Supply ppm	Zn Content of Shoots mg/Kg Dry Wt	Dry Wt of Shoots g	No. of Tillers per Plant	Per cent Tillers over 150 cm	Per cent Flowering Tillers	No. of Seeds per Plant
0·0	18 ± 1	114·1	40·0	41·6	8·5	27·8
0·001	12 ± 1	92·4	42·2	13·8	15·9	124·0
0·005	9 ± 1	100·8	34·2	48·2	3·1	1·2
0·01	20 ± 3	104·5	29·0	43·6	16·4	77·6
0·05	23 ± 3	105·3	40·4	29·2	14·2	40·4
0·1	18 ± 1	110·8	45·4	36·4	14·1	27·0
0·5	26 ± 2	94·6	41·2	30·0	22·9	17·4
1·0	48 ± 6	104·4	46·2	34·1	11·5	160·0
5·0	235 ± 31	93·7	45·6	27·7	17·4	150·6
10·0	382 ± 32	105·1	54·2	18·2	15·5	51·4
100	6,533 ±1,883	8·75	9·8	14·2	0	0
200	14,377 ±5,155	2·80	3·6	2·7	3·3	0·2
L.S.D. (P = 0·05)		24·6	14·7	16·3	20·2	—
(P = 0·01)		32·8	19·6	21·8	27·0	—

any consistent relation to treatment or to the internal concentration of Zn; the percentage of long tillers tended to decrease with applications of 10 ppm or more of Zn.

The effects of Zn upon flowering were also extremely variable and most differences were not statistically significant. The lowest percentage of flowering tillers per plant were obtained with 0·005, 100 and 200 ppm of Zn. About 60% of the plants in each treatment up to 10 ppm of Zn flowered; only with 0·5 ppm of Zn did all the plants flower.

Seed production also varied considerably and showed no consistent relation to treatment, except that practically no seeds were produced by plants supplied with 100 and 200 ppm of Zn. Best seed production was obtained with 1 and 5 ppm of Zn.

From the results it would seem that a deficiency of Zn would only develop in plants with an internal level of Zn of less than 9 mg per Kg dry weight, and that *S. sphacelata* is able to accumulate fairly large amounts of Zn (up to about 400 mg per Kg dry tissue) without apparent injury or retardation of growth. Although it is not possible to define an optimal level of Zn application, amounts above 10 ppm in the medium would appear to be supra-optimal.

CONCLUSIONS

Of the four micronutrient elements investigated, only manganese was definitely shown to be required for normal growth and development of *Setaria sphacelata* in sand culture. Not only did the plants show definite symptoms of deficiency in the absence of Mn, but growth was greatly improved and the deficiency symptoms were absent at Mn levels of 0·5 ppm and above. In addition, the plants appear to be more tolerant to high levels of Mn than to comparable levels of any of the other three elements.

Although no definite symptoms of a deficiency of boron developed in the main sand culture experiment, boron also appears to be required for normal growth and development. This was indicated by the development of some symptoms of disturbed growth in the minus-boron plants during the accompanying water-culture and the second sand-culture experiments. It is also possible that the increased tillering, coupled with the reduction in tiller length observed in those plants receiving 0·001 ppm of B in the main sand-culture experiment, might indicate the development of an incipient deficiency of boron.

The absence of deficiency symptoms or specific growth effects in those plants receiving little or no Cu or Zn, together with the fact that some of them contained as little as 8 mg Cu and 9 mg Zn respectively per Kg of dry material, seem to indicate that *S. sphacelata* has a relatively low requirement for these elements, as compared to B and Mn. Analysis of the original seed showed it to contain 19 mg B, 102 mg Mn, 355 mg Cu and 324 mg Zn per Kg of dry matter. Since the seeds weigh about one milligram apiece, it appears that contamination from outside sources had not been eliminated completely.

In view of the results obtained, one would expect deficiencies of Cu and Zn to be less likely than those of Mn (or even of B) under field conditions. On the other hand, the sensitivity of the plants to Cu levels as low as one ppm would indicate that this element might have deleterious effects on their growth under certain circumstances.

Acknowledgements

One of us (J. A. de B.) wishes to thank the University of Chicago, the South African Council for Scientific and Industrial Research and the Visser Agricultural Research Fund for fellowship support received during the course of this investigation. This study was supported in part by a grant from the Dr. Wallace C. and Clara A. Memorial Fund of the University of Chicago. The seed of *Setaria sphacelata* was kindly supplied by the Pasture Research Section of the Agricultural Research Institute, Potchefstroom.

References

Bear, F. E., & Coleman, R. (Ed.) (1949): Hunger Signs in Crops. 2d Ed. Amer. Soc. Agron. and Nat. Fert. Assoc., Washington, D.C.

Beeson, K. C., Gray, L. & Adams, M. B. (1947): The absorption of mineral elements by forage plants. I. The phosphorus, cobalt, manganese and copper content of some common grasses. *J. Amer. Soc. Agron.* **39** : 356–362.

Berger, K. C., & Truog, E. (1944): Boron tests and determination for soils and plants. *Soil Sci.* **57** : 25–36.

Cook, J. W. (1941): Rapid method for determining manganese in feeds. *Ind. Eng. Chem., Anal. Ed.* **13** : 48–50.

Cowling, H., & Miller, E. J. (1941): Determination of small amounts of zinc in plant materials. *Ind. Eng. Chem., Anal. Ed.* **13** : 145–149.

Eden, A., & Green, H. H. (1940): Micro-determination of copper in biological material. *Biochem. J.* **34** : 1202–1208.

Gizzard, A. L., & Matthews, E. M. (1942): The effect of boron on seed production of alfalfa. *J. Amer. Soc. Agron.* **34** : 365–368.

Goodall, D. W., & Gregory, F. G. (1947): Chemical composition of plants as an index of their nutritional status. Imp. Bur. Hort. Plant. Crops, Tech. Commun. **17**.

Hasler, A., & Maurizio, A. (1947): Die Wirkung von Bor auf Samensatz und Nektarsekretion bei Raps (*Brassica napus* L.). *Phytopath. Zeitschr.* **15** : 193–207.

Hoagland, D. R., & Arnon, D. I. (1950): The water-culture method for growing plants without soil. Calif. Agr. Exp. Sta. Circ. 347.

Hodges, E. M., Killinger, G. B., & Carrigan, R. A. (1945): Effect of minor elements on the establishment and growth of pasture plants. Florida Agr. Exp. Sta. Ann. Rep. 1945: 131–132.

Morris, H. S. (1931): Physiological effects of boron on wheat. *Bull. Torrey Bot. Club* **58** : 1–30.

Reed, H. S. (1942): The relation of zinc to seed production. *J. Agr. Res.* **64** : 635–644.

Schropp, W., & Arendz, B. (1940): Versuche mit Bor zu einigen Gramineen. *Bodenk. u. Pflanzenernähr.* **16** : 169–184. (C.A. 34, 2885).

Snedecor, G. W. (1956): Statistical Methods. 5th Ed. Iowa State College Press, Ames.

Sommer, A. L. (1927): The search for elements essential in only small amounts for plant growth. *Science* **66** : 482–484.

Steinberg, R. A. (1935): Nutrient-solution purification for removal of heavy metals in deficiency investigations with *Aspergillus niger*. *J. Agr. Res.* **51** : 413–424.

Stout, P. R., & Arnon, D. I. (1939): Experimental methods for the study of the role of copper, manganese, and zinc in the nutrition of higher plants. *Amer. J. Bot.* **26** : 144–149.

Wallace, T. (1951): The Diagnosis of Mineral Deficiencies in Plants by Visual Symptoms. 2d. Ed. H.M.S.O., London.

Warmke, H. E. (1952): Apomixis in grasses, with special reference to *Panicum maximum*. Proc. Sixth. Int. Grassl. Congr. I: 209–215.

Weinmann, H. (1951): Effects of certain minor elements on *Paspalum dilatatum* grown in Marandellas Sandveld Vlei. *S. Afr. J. Sci.* **48** : 25–26.

Williams, R. D. (1951): The effects of deficiencies of several trace elements on timothy (*Phleum pratense*) grown in culture solution. *Plant and Soil* **3** : 257–266.

Wood, J. G., & Sibly, P. M. (1950): The distribution of zinc in oat plants. *Austral. J. Sci. Res.* **B3** : 14–27.

CYTOGENETIC STUDIES IN THE GENUS *ORNITHOGALUM* L.

IV. THE CYTOGENETICS OF INTER- AND INTRASPECIFIC CROSSES INVOLVING *O. THYRSOIDES* JACQ. AND *O. LACTEUM* JACQ.*

T. J. Roos† and R. de V. Pienaar‡

ABSTRACT

Meiotic and fertility investigations were made of two inter- and intraspecific hybrids involving *O. thyrsoides* and *O. lacteum* in order to obtain cytotaxonomic data regarding the genetic relationship between the parental species.

No viable hybrids between the *O. lacteum* forma nov. from Sutherland ($2n = 10$) and other typical *O. lacteum* ($2n = 12$) biotypes have as yet been produced. However, viable, but sterile hybrids with *O. thyrsoides* from Bokbaai ($2n = 12$) have been obtained. It is doubtful whether the Sutherland form is in fact an *O. lacteum* biotype.

O. thyrsoides (Bokbaai) and *O. thyrsoides* (Sandveld) are two phenotypically very different biotypes, kept intact by mere geographical isolation.

INTRODUCTION

As pointed out by Stebbins, Dobzhansky, Lewis and others, (cf. Roos and Pienaar, 1966b) isolating mechanisms are fundamental in speciation. In studies concerning the relationship between taxa, the detection of barriers to gene exchange is of prime importance. The degree of gene exchange or its absence provides a measure of genetic relationship and enables a true classification.

Since Turesson's (1922) original studies in gene-ecology three biosystematic categories are being distinguished, viz. the cenospecies, ecospecies and ecotype, depending upon the absence or degree of gene exchange (cf. Clausen, 1951). A consideration of taxa in terms of these categories permits a more precise concept regarding their evolutionary relationship and taxanomic rank.

Since no major karyotypic differences could be detected between biotypes of *O. lacteum* and *O. thyrsoides* (Roos and Pienaar, 1966*a* and *b*) fertility studies and meiotic analyses were conducted upon their inter- and intraspecific hybrids in an effort to clarify their taxonomic relationship.

---

* Part of thesis submitted by the senior author in partial fulfilment of the requirements for the degree of M.Sc. in Agriculture at the University of Stellenbosch.

† Fruit and Food Technology Research Institute, Stellenbosch.

‡ Department of Genetics, S.E. College of Agriculture, Stellenbosch.

MATERIALS AND METHODS

F_1 material from the following crosses and their parental species were fixed and treated as specified by Pienaar (1955): *O. thyrsoides* (Bokbaai) × *O. lacteum* forma nov. (Sutherland), *O. thyrsoides* (Bokbaai) × *O. thyrsiodes*) Sandveld).

RESULTS

From the large number of cross pollinations made between *O. lacteum* and *O. thyrsoides* biotypes the examples depicted in Table I give a good indication of the results obtained. Except for the hybrid no. 1269 mentioned below, no hybrids between the two species resulted from these reciprocal crosses.

TABLE I.
RECIPROCAL CROSSES BETWEEN *O. LACTEUM* JACQ. AND *O. THYRSOIDES* JACQ.

♂ ♀	*O. lacteum* Darling	*O. lacteum* forma nov. Sutherland	*O. thyrsoides* Bokbaai	*O. thyrsoides* Sandveld
O. lacteum Darling	+	—	—	—
O. lacteum forma nov. Sutherland	—	+	—	—
O. thyrsoides Bokbaai	—	×	+	×
O. thyrsoides Sandveld	—	—	×	+

× = viable hybrids.
— = no seeds set with viable embryos.
+ = pure bred plants.

Very few seeds were set in the cross between *O. thyrsoides* from Bokbaai ($2n = 12$; Fig. 1*a*) and *O. lacteum* forma nov. from Sutherland ($2n = 10$; Fig. 1*b*), producing hybrid no. 1269 ($2n = 11$; Fig. 1*c*). On the other hand, good seed set was obtained in the cross between *O. thyrsoides* from Bokbaai and *O. thyrsoides* from Sandveld ($2n = 12$; Fig. 1*d*), producing hybrid no. 1288.

Data of measurements conducted upon the pollen grains of the species and hybrids are summarized in Table II.

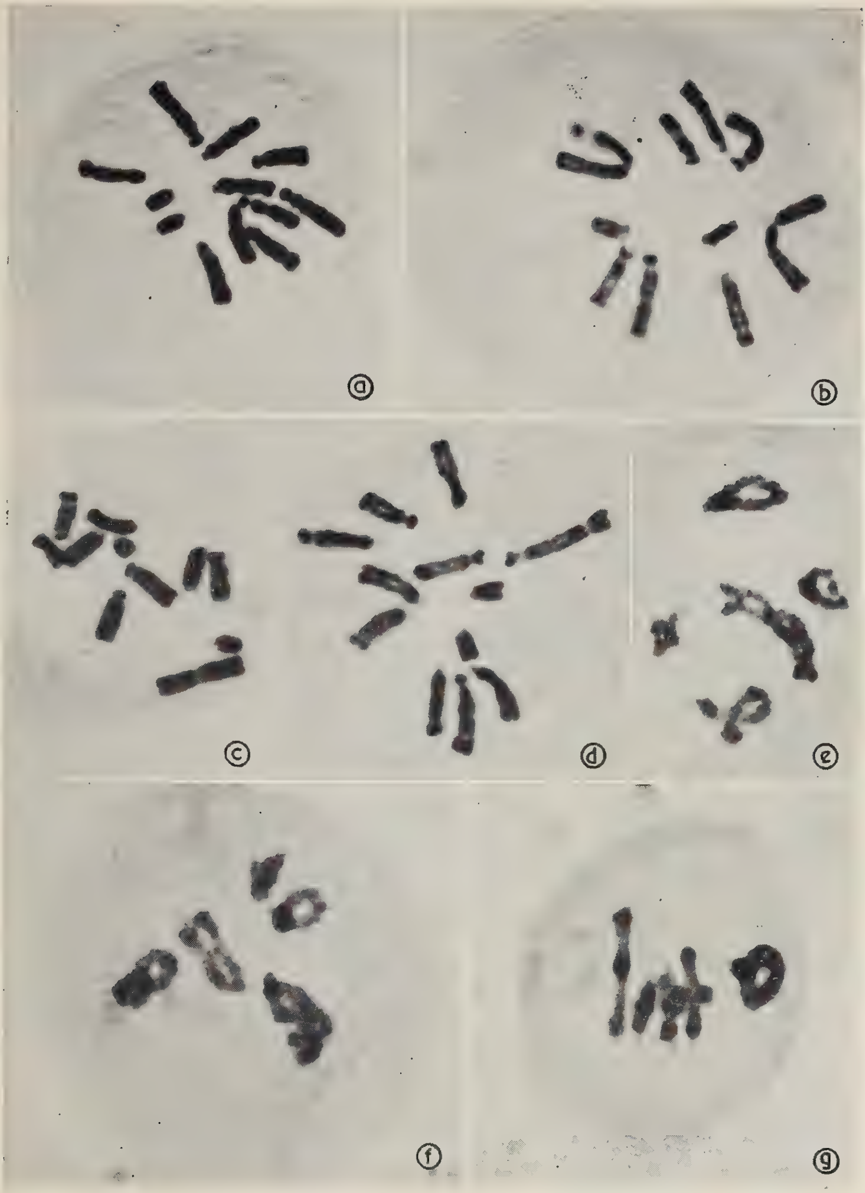


FIG. 1. (*a—d*) C-metaphase plates from root tip cells of *Ornithogalum* species and hybrids, × 2,000; (*a*) *O. thyrsoides* from Bokbaai; (*b*) *O. lacteum* forma nov. from Sutherland; (*c*) Hybrid no. 1269 = *O. thyrsoides* (Bokbaai) × *O. lacteum* forma nov. (Sutherland); (*d*) *O. thyrsoides* from Sandveld. (*e—g*) Meiotic stages in *O. lacteum* forma nov. from Sutherland, × 1500: (*e* and *f*) Diakinesis; (*g*) Metaphase I.

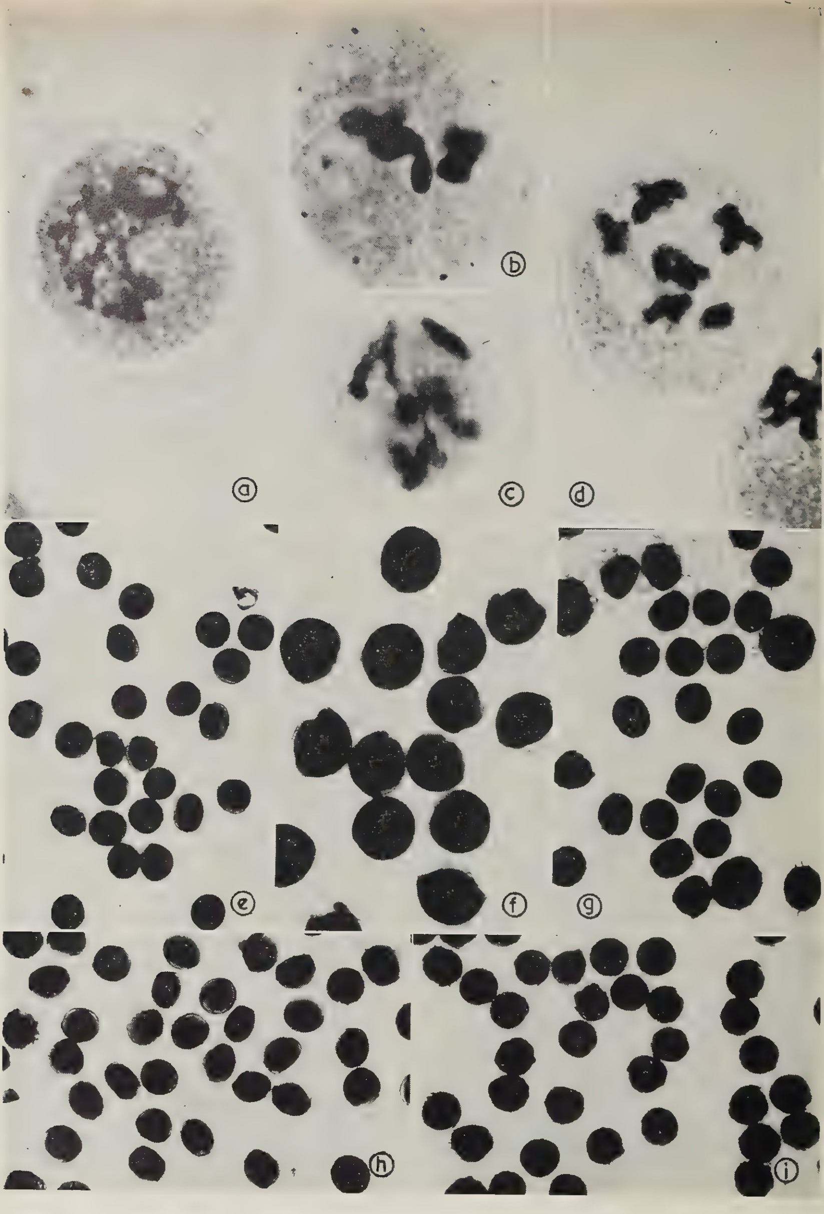


FIG. 2. (*a—c*) Meiotic stages in hybrid no. 1269, viz. *O. thyrsoides* (Bokbaai) × *O. lacteum* forma nov. Sutherland, × 1500; (*a*) Meiotically inhibited PMC from an advanced bud; (*b* and *c*) Metaphase I stages from a younger bud from a second plant; (*d*) Diakinesis in PMC from hybrid no. 1288, viz. *O. thyrsoides* (Bokbaai) × *O. thyrsoides* (Sandveld). (*e—i*) Glycerine-aceto-carmine stained pollen grains from various *Ornithogalum* species and hybrids, × 250; (*e*) *O. thyrsoides* from Bokbaai; (*f*) hybrid no. 1269, viz. *O. thyrsoides* (Bokbaai) × *O. lacteum* forma nov. (Sutherland); (*g*) *O. lacteum* forma nov. from Sutherland; (*h*) hybrid no. 1288, viz. *O. thyrsoides* (Bokbaai) × *O. thyrsoides* (Sandveld); (*i*) *O. thyrsoides* from Sandveld.

TABLE II.

NUMBER OF APPARENTLY VIABLE (CARMINE STAINED) AND INVIABLE POLLEN GRAINS, AND THE DIAMETER OF "VIABLE" POLLEN, MEASURED IN μ.

Plant	Number of pollen grains counted	Number of stained pollen grains	Percentage "viable" pollen grains	Mean diameter μ	Standard deviation
O. thyrsoides (Bokbaai)	533	512	96·1	55	± 3·5
O. lacteum forma nov. (Sutherland)	525	489*	93·1	57	± 5·2
Hybrid 1269	458	413	90·2	95	± 5·1
O. thyrsoides (Sandveld)	554	545	98·4	61	± 3·7
Hybrid 1288	705	653	92·6	61	± 3·6

* 7% of these pollen grains had a volume twice that of the haploid pollen grains and were considered to be diploid (cf. Fig. 2g).

Hybrid no. 1269 produced about 90·2% apparently viable pollen grains, all of which were exceptionally large (Fig. 2*f*). A chromosome count of their generative nuclei at late prophase revealed that the pollen grains were tetraploid. This rather irregular phenomenon was studied in detail by analysing a series of flower buds at successive stages of development. The series extended from pre-leptonema stages up to fully differentiated pollen grains.

Leptonema, zygonema and pachynema appeared normal. However, it was noted that very few microsporocytes passed the pachynema-diplonema stage. This stage was maintained in a few successive flowers, after which it appeared to revert back towards interphase (Fig. 2*a*). At about this stage the differentiation leading to the formation of the pollen grains started, and resulted in typically thick-walled pollen grains in which no meiotic reduction of chromosome number had taken place (Fig. 2*f*).

A few microsporocytes were noted in which meiosis did proceed to metaphase I and anaphase I (Fig. 2*b* and *c*). In these microsporocytes the chromosomes were clumped together to such an extent at diakinesis and metaphase I (probably due to the onset of degeneration), that no analysis of pairing and chiasma formation was possible. Some formed diads and very infrequently tetrads were produced, but all soon degenerated.

It appears therefore, that after a prophase reversal from the zygonema-pachynema stage, the majority of microsporocytes in this hybrid differentiate into unreduced pollen grains. The fact that the unreduced microsporocytes could continue development into pollen grains must be ascribed to their possession of a balanced tetraploid chromosome complement (cf. Roos and Pienaar, 1966*b*).

Data concerning the chromosome associations and chiasma frequencies at diakinesis of the *O. lacteum* forma nov. from Sutherland are summarized in Table III. From these data it is evident that in the *O. lacteum* forma with $2n = 10$, the total number of chiasmata per PMC (10·9) and mean number of chiasmata per bivalent (2·2) are similar to that found in *O. thyrsoides* ($2n = 12$) in which the respective chiasma frequencies are 12·7 and 2·1 (Table V). The large bivalent produced by the synapsed metacentric chromosomes had a chiasma frequency of 3·6, which was twice that of the mean number of chiasmata (1·8) occurring in each of the other four bivalents formed by the acrocentric chromosomes.

TABLE III.

CHROMOSOME ASSOCIATIONS AND CHIASMA FREQUENCIES AT DIAKINESIS OF *O. LACTEUM* FORMA NOV. FROM SUTHERLAND.

Chromosome associations		Number of cells scored	Number of chiasmata per bivalent*					Number of chiasmata per cell	Standard deviation	Mean number of chiasmata per chromosome pair
I	II		1	2	3	4	5			
	5	21	3·5	2·4	2·1	1·4	1·9	11·3	± 1·9	2·3
2	4	4	4·0	2·0	0·8	0·2	2·0	9·0	± 0·7	2·2
Total		25	3·6	2·3	1·9	1·2	1·9	10·9	± 0·8	2·2

* The individual bivalents could be distinguished on account of size differences and was numbered *1–5*; *1* being the bivalent formed by the two large metacentrics, and *5* the bivalent formed by the two smallest homologues.

Hybrid no. 1288 was an intraspecific cross between the *O. thyrsoides* biotype from Bokbaai as the female parent and the *O. thyrsoides* biotype from Sandveld as the male parent. Although the two biotypes are phenotypically very different, reciprocal crosses were readily made to give fertile hybrids (Table I). The Bokbaai biotype blooming early in October, has a 6″ peduncle suspending a raceme of large, wide opening, light cream coloured flowers having brown centres, while the Sandveld biotype, blooming late in November, is approximately 3′ tall and has smaller, white, cup-shaped flowers. These phenotypic differences were maintained even when both were subjected to the same environmental conditions.

In Table II it can be seen that hybrid no. 1288 formed 92·6% normal haploid pollen (Fig. 2*h*), which was very similar to that produced by the pure biotypes. A detailed study of the chromosome associations and chiasma frequencies at diakinesis and MI in this hybrid revealed a close similarity between the karyotypes of the two biotypes (Table IV and Fig. 2*d*).

TABLE IV.

CHROMOSOME ASSOCIATIONS AND CHIASMA FREQUENCIES AT DIAKINESIS OF THE HYBRID *O. THYRSOIDES* (BOKBAAI) × *O. THYRSOIDES* (SANDVELD).

Chromosome associations				Number of cells scored	Number of chiasmata per cell	Standard deviation	Mean number of chiasmata per chromosome pair
I	II	III	IV				
	6			33	14·5	±1·05	2·4
2	5			17	11·9	±1·40	2·0
Total				50	13·6	±0·83	2·2

Although a few univalents were noted, mostly bivalent associations were formed. Compared to the chiasma frequencies in one of the parents (Table V), the mean of 13·6 chiasmata per cell in the hybrid is indicative of a close resemblance between the homologous chromosomes from the two parental biotypes.

TABLE V.

CHROMOSOME ASSOCIATIONS AND CHIASMA FREQUENCIES AT DIAKINESIS OF *O. THYRSOIDES* JACQ. (SANDVELD).

Chromosome Associations				Number of cells scored	Number of chiasmata per cell	Standard deviation	Mean number of chiasmata per chromosome pair
I	II	III	IV				
	6			16	12·9	±1·22	2·2
2	5			4	12·3	±0·47	2·1
Total				20	12·7	±1·19	2·1

The development of the pollen grains of hybrid no. 1288 were almost normal and reflected their balanced genomic constitution. The absence of detrimental interactions between the maternal cytoplasm and the reduced hybrid nucleus is further evidence of the genetic homology between the two biotypes.

DISCUSSION AND CONCLUSIONS

The hybrid between *O. thyrsoides* (Bokbaai $2n = 12$) and *O. lacteum* forma nov. (Sutherland $2n = 10$) must be regarded as exceptional in that this latter *O. lacteum* forma has as yet failed to produce hybrids with any of the other *O. lacteum* or *O. thyrsoides* ecotypes with which it was reciprocally crossed. No viable haploid pollen grains are formed by the hybrid. Potentially viable pollen grains appear to be tetraploid.

The pollen grains are tetraploid because no meiotic anaphase followed the chromosomal division during prophase in the PMC's; instead, the chromatids separate endomitotically causing the chromosome number in the nucleus to reduplicate. The fact that the unreduced microsporocytes can continue development into pollen grains must be ascribed to their possession of a balanced tetraploid chromosome complement (cf. Roos and Pienaar, 1966*b*).

A meiotic investigation of the diakinesis and MI stages in the *O. lacteum* forma from Sutherland (Table III, and Fig. 1*e—g*) did not reveal any abnormalities or polyploid PMC's. However, it is clear from fig. 2*g* that apart from the normal haploid pollen grains a fair number of diploid pollen grains are produced, in fact 7%. It is quite conceivable that the genetic factor which is responsible for this phenomenon is triggered into operation at an earlier stage in the genetically more unbalanced hybrid, causing the suppression of the post pachytene meiotic stages and inducing the PMC's to differentiate directly into the large tetraploid pollen grains. Although a few seeds were set by the hybrid after self-pollination and backcrossing, no progeny could be raised from them.

It was rather disappointing that meiotic pairing could not be followed in the hybrid as the paring between the large metacentric chromosome of the *O. lacteum* forma and the homologous chromosomes in the haploid set furnished by the *O. thyrsoides* parent, could have vindicated the hypothesis of Roos and Pienaar (1966*a*) regarding the origin of the metacentric chromosome in the karyotype of the *O. lacteum* forma. If their hypothesis, that this chromosome resulted from a centric union (due to a translocation in the centromere region) between two acrocentric chromosomes, is correct, then a trivalent consisting of the metacentric chromosome and two acrocentric chromosomes, with the three centromeres lying close together, should have been formed during meiosis. However, the fact that in the *O. lacteum* forma nov. the large bivalent formed by the metacentric homologues has a chiasma frequency twice that in each of the other bivalents (produced by synapsed acrocentric chromosomes) lends credence to the supposition that the metacentric chromosome resulted from a centric union between two acrocentric chromosomes and not from a pericentric inversion (cf. Table III).

In the light of the evidence given above it is considered unlikely that the *O. lacteum* forma nov. from Sutherland represents an *O. lacteum* biotype. Genetically it behaves like a separate species which can be cytologically indentified (Pienaar, 1963; Roos and Pienaar, 1966*a*).

The normal meiosis, gamete production and high fertility of the F_1 hybrid resulting from the cross between the Bokbaai and Sandveld biotypes of *O. thyrsoides* revealed the absence of an intrinsic barrier to gene exchange between them, and showed that these two morphologically distinct biotypes are kept intact merely by geographical isolation. Biosystematically they are two ecotypes of the same cenospecies.

ACKNOWLEDGEMENTS

The authors are indebted to the Department of Agricultural Technical Services for making this study possible.

References

Clausen, J., (1951). Stages in the Evolution of Plant species. Hafner Publ. Co., N.Y.

Leighton, F. M. (1944). A revision of the South African species of *Ornithogalum L.* Part I. *Journ. S. Afr. Bot.*, X: 83–110.

————, (1944). Part II. *Journ. S. Afr. Bot.*, X: 111–122.

————, (1945). Part III. *Journ S. Afr. Bot.*, XI: 135–189.

Pienaar, R. de V., (1955). Combinations and variations of techniques for improved chromosome studies in the *Gramineae*. *Journ S. Afr. Bot.*, XXI: 1–9.

———— (1963). Sitogenetiese studies in die genus *Ornithogalum* L. I. Inleidende oorsig. *Journ. S. Afr.* Bot., XXIX: 111–130.

Roos, T. J. and Pienaar, R de V. (1966). Cytogenetic studies in the genus *Ornithogalum* L. II. Karyotype analyses in some biotypes of *O. conicum* Jacq., *O. lacteum* Jacq., and *O. thyrsoides* Jacq. *Journ. of S. Afr. Bot.*, XXXII: 211-227.

———— (1966). Cytogenetic studies in the genus *Ornithogalum* L. III. Meiotic analysis of some interspecific hybrids of *O. conicum* Jacq. and *O. lacteum* Jacq. *Journ. of S. Afr. Bot.*, XXXII: 261-271.

Turesson, G., (1922). The genotypical response of the plant species to the habitat. *Hereditas*, 3: 341–347.

Addendum

In Part III of this series the symbol MI in tables III, IV, V and VI should be read to mean meiosis 1 (stage: diakinesis) and not metaphase I. On page 266 paragraph 1 read diakinesis instead of metaphase I.

NOTES ON MESEMBRYANTHEMUM AND ALLIED GENERA

H. M. L. Bolus

Drosanthemum crassum L. Bol. sp. nov. (*Aspericaulia-Gracilia*).—Planta 1 visa, fera, rigida robusta glabra polita, cuticula atre brunnea, 26 cm. alta; caulis ca. 3 cm. longus, 2·5 cm. diam.; rami primarii flexuosi, 1—1·4 cm., secondarii ca. 8 mm., diam.; ramuli ultimi floriferi gracillimi pallidi, minute papillati, 4—6-foliati, vix 0·75 mm. diam.; folia ascendentia vel patentia, fere teretia vel subglobosa, apice rotundo, viridia, papillis inconspicuis, vix nitentibus, saepius 5—8 mm. longa, ad 3 mm. diam.; flores solitarii pomeridiani, 1·5—2 cm. diam.; pedunculi gracillimi persistentes, demum indurati, fere subspinescentes, saepius 7—15 mm. longi; receptaculum obconicum, 3 mm. longum diametroque; sepala 5, subaequilonga, obtusa vel subacuta, 3—4 mm. longa, basi 1·5—2 mm. lata, interiora anguste marginata; petala ca. 3-seriata, e parum infra medium leviter angustata, saepius obtusa, ad 1 cm. longa, ad 1·25 mm. lata; staminodia nulla; glandulae approximatae; ovarium circa marginem concavum, lobis distantibus medio vix ad 0·5 mm. elevatis, stigmata 5, gracillima, 4 mm. longa.

Cape Province: in dit. Ladismith; "near the village of Radleigh, about 7 miles S. of Calitzdorp, plentiful in karroid scrub", Dec. 1963, *H. Hall* 2729.

This species, in spite of its unusually robust habit of growth, has the slender ultimate flowering branchlets which characterise the Subgroup *Gracilia*.

Trichodiadema pygmaeum L. Bol. sp. nov. (*Stricta*).—Plantae ferae plures visae, caespitosae, 1—1·5 cm. altae, ad 5 cm. diam.; radices graciles reptantes, ad 25 cm. longi, 1—3 mm. diam.; caulis 6—10 mm. diam.; partes herbaceae papillatae, papillis setiferis; rami primarii ad 2 cm. longi, internodiis inclusis, inferne reliquiis crebis vestiti; ramuli ultimi floriferi ca. ad 1·2 cm. longi; folia ascendentia semiteretia, prope apicem angustata, saepius inconspicue barbata, setis erectis vel ± patentibus, capillaceis, ad 6 mm. longa, ad 3 mm. lata; flos 1 visus, meridianus, subsessilis vel pedunculo in fructu immaturo 3 mm. longo; receptaculum globose obconicum, 2·5 mm. longum, 4 mm. diam.; sepala 5, 3—4 mm. longa, basi 1·5 mm. lata; petala ca. 2—seriata, e prope medium inferne angustata, obtusa rosea, 5—8 mm. longa, ad 1·5 mm. lata; staminodia nulla; filamenta ca. 3-seriata, conferta, inferne rosea, superne roseo purpurea, ca. 2 mm. longa, intima prope medium papillata, antheris pollineque luteis; glandulae subapproximatae crenulatae; ovarii lobi fere erecti, obtusa compressi, ad 0·75 mm. elevati; stigmata 5, anguste subulata, brevissime caudata.

Cape Province: in dit. Swellendam, St. Sebastian Bay, Cape Infanta; Jul. 1966, *Margaret Thomas*. Bolus Herbarium 27823.

Cephalophyllum pulchellum L. Bol. forma (*Caespitosa*).—Planta 1 visa, ad 6 cm. alta, ad 12 et 17 cm. diam.; caulis 2 cm. diam.; rami primarii ad 4 cm. longa, ad 8 mm. diam.; reliquiis dense vestiti; petala primum lutea, deinde superne carnea; antherae sordide purpureae, polline griseo; stigmata alba; capsulae senectae tantum visae, 1 cm. expansae, 1·8 cm. diam., infra breviter crateriforiformes, ad 3 mm. longae, supra per 2 mm. elevatae, suturis compressis, tuberculo conspicuo albo, valvis valde recurvis, carinis superne leviter patentibus, alis apicem valvae attingentibus.

Cape Province: Namaqualand; Komkans, "fairly plentiful in quartz patches amongst **Conophytum komkansicum**," Jul. 1966, *H. Hall* 3067. NBG 466/66.

The following species are described from dried material and drawings in colour made from living specimens by Miss B. O. Carter.

Aridaria klaverensis L. Bol. sp. nov.—Planta 1 visa, fera robusta, ad 90 cm. alta; rami atre brunnei, ad 1 cm. diam.; ramuli ultimi floriferi cum flore ad 6·5 cm. longi, ad 1·5 mm. diam., internodiis ad 1·1 cm. longis; folia ascendentia vel fere erecta vel alterum fere erectum alterumque subfalcatum, semiteretia, supra plana, lateraliter visa interdum superne angustata acutaque, dorso rotundo, viridia, ad 2·2 cm. longa, ad 3 mm. lata diametroque; cymae 3-florae; pedunculi terminales 5—10 mm., laterales ad 1·2 cm., longi propeque medium bracteolati, bracteolis 4—7 mm. longis; flores meridiani, 1·5—2·5 cm. diam.; receptaculum ca. 3 mm. longum, ad 6 mm. diam.; calycis tubus 2 mm. longus, segmentis variabilibus, in alabastris obtusis subaequilongis, 5—6 mm. longis, basi 3—4 mm. latis, in flore maturo exterioribus acuminatis ad 10 mm. longis, basi 2—3 mm. latis, interioribus 4—5 mm. vel 4—8 mm., longis, basi 2—5 mm. latis, brevissimo latissimo ampleque marginato, vel 2 exterioribus subaequilongis et 2 interioribus brevioribus subaequilongis; petala ca. 3-seriata, basi per 1·5 mm. coalita, obtusa alba, ad 1·7 cm. longa, et ad 1 mm. lata in flore maximo viso; stamina ca 8-seriata, ad medium corollae attingentia, antheris pollineque pallide luteis; ovarium inferius, lobis leviter compressis, apice obtusis, ad 2 mm. elevatis; stigmata erecta gracilia fere ad apicem minutissime papillata, ad 8 mm. longa.

Cape Province: in dit. Vanrhynsdorp, Klaver, Aug. 1932, *L. Bolus*. NBG 1978/32. (Typus). Inter Nieuwerust et Garies *F. M. Leighton*. Bolus Herbarium 27824.

Aridaria beaufortensis L. Bol. sp. nov.—Rami plures visi, ad 25 cm. longi, internodiis 1·5—3 cm. longis, cuticula pallida vel demum grisea; folia ascendentia vel patentia vel subfalcata, lateraliter visa prope apicem leviter angustata, obtusa, glauce viridia, 1·5—2 cm. longa, 2—3 mm. diam.; cymae laxe ternatae vel 2-ternatae, ad 12 cm. diam., ramis ascendentibus vel demum incurvis; pedunculi ad 4·5 cm. longi; flores nocturni odoratissimi, 3 cm. diam.; receptaculum conspicue decurrens itaque quasi piriforme, 6 mm. longum, 8 mm. diam.; calycis tubus 3 mm. longus, segmentis 7—9 mm. longis vel aequilongis, ad 9 mm. longis, basi 5—8 mm. latis, e medio foliiformibus; petala in flore maximo viso 1·8 cm. longa, basi per 3 mm. coalita, obtusa vel acuta, alba, externe pallide citrina; stamina ca. 7-seriata, medium corollae superantia; ovarium inferius, lobis ad 3 mm. elevatis; stigmata erecta gracilia, prope basim levissime incrassata, longe attenuata, 5 mm. longa.

Cape Province: in dit. Beaufort West; Beaufort, *Ina de Jager*. Bolus Herbarium 27822. Fl. hort. L. Bolus Oct. 1928.

Aridaria leipoldtii L. Bol. sp. nov.—Planta 1 visa, fera senectissima, ca. 17 cm. alta, caule 2·3 cm. diam., copiose ramosa ramulosaque; rami primarii purpureo brunnei, ad 1·5 cm. diam.; ramuli hornotini floriferi graciles rubidi, ad 8 cm. longi, 0·75—1 mm. diam., internodiis 1·5—2·5 cm. longis; folia fere erecta, vel ascendentia vel patentia, teretia, lateraliter visa prope apicem interdum leviter angustata, apice rotundo vel obtuso vel rarius subacuto, 1·2—1·8 cm. longa, medio 3—5 mm. diam.; cyma 3-fl., immatura ut videtur; flores nocturni; pedunculi 4—8 mm. longi; receptaculum suboblongum, in pedunculum decurrens, ca. 4 mm. longum, apice 5—6 mm. diam.; calycis tubus ca. 4 mm. longus, segmentis subaequilongis, ad 5 mm. longis, vel inaequilongis, 4—7 mm. longis, basi 2—4 mm. latis; petala ca. 3—4-seriata, parum inaequilonga, basi per 4 mm. coalita, interiora acuta, extima obtusa, intus inferne pallida, superne rosea, externe rubra, ad 2·7 cm. longa, 0·5—1 mm. lata; stamina ad 11-seriata, extima ultra medium petalorum extimorum attingentia, antheris pollineque pallidis; ovarium semi superius, lobis obtusis, ad 3·5 mm. elevatis; stigmata e basi leviter patentia, deinde erecta, 9 mm. longa.

Cape Province: in dit. Clanwilliam; inter Clanwilliam et Eland's Kloof, Sept. 1933. *C. L. Leipoldt*. Bolus Herbarium 21243.

Aridaria pillansii L. Bol. sp. nov.—Planta 1 visa, ca. 24 cm. alta, caule ad 1·6 cm. diam.; rami primarii ad 5 mm., ultimi floriferi ad 1·5 mm., diam., cuticula grisea, internodiis 1—2 cm. longis, folia ascendentia vel patentia, teretia, subglauce viridia, ad 1·2 cm. longa, ad 4 mm. diam.; cyma laxissime 3-ternata, 13·5 cm. longa, 18 cm. diam., ramis incurvis; flores nocturni, 2·5 cm. diam.; receptaculum 5 mm. longum, apice 5·5 mm. diam.; calycis tubus fere 4 mm. longus, segmentis obtusis, in alabastris subaequalibus foliiformibus, demum exterioribus ad 9 mm., interioribus 6—7 mm., longis, basi 4—7 mm. latis;

petala 5-seriata, basi per 3 mm. coalita, intima acuminata, exteriora leviter emarginata, intus inferne subalba, superne pallide rosea, ad 1·2 cm. longa, vix ad 1 mm. lata; stamina ca. 5-seriata, ad 6 mm. longa, antheris pollineque luteis; ovarium partim superius, lobis leviter compressis, apice obtuso, ad 3 mm. elevatis; stigmata inferne subulata (crassissima adhuc in genere notata) papillata, superne caudata, 4 mm. longa, cum cauda 2 mm. longa.

Cape Province: Namaqualand; Richtersveld, Oct. 1926, *N.S. Pillans* 6042. Fl. hort. Pillans Mart. 1928.

Aridaria nevillei L. Bol. sp. nov.—Rami 4 visi, culti, ad 16 cm. longi, basi 3 mm. diam., internodiis 1—1·8 cm. longis; folia ascendentia vel patentia vel subfalcata, supra plana, lateraliter visa obtusa, 1·5—2·7 cm. longa, 2—4 mm. diam.; cyma 1 visa, 3-flora cum flore clauso 6 cm. longi, ca. 7 cm. diam., flore primum vespertino, deinde per diem clausissimo, demum senecto, cum petalis valde recurvis sed tamen normalibus, per diem aperto manente; receptaculum 5 mm. longum, ad 9 mm. diam., longissime decurrens; calycis tubus ca. 6 mm. longus, segmentis exterioribus obtusis, 8—10 mm. longis, basi 5—6 mm. latis, interioribus acutis, 6—7 mm. longis; petala ca. 3-seriata, basi per 3 mm. coalita, acuta vel obtusa vel emarginata, inferne alba, superne externeque brunneo rosea, 1·6—2·2 cm. longa, 0·5—1 mm. lata; stamina ca. 7-seriata, ad 1·4 cm. longa, antheris primum 1·5 mm. longis, cum polline luteis; ovarium fere omnino inferius, lobis obtusis, ca. ad 3 mm. elevatis; stigmata basi per 2 mm. anguste subulata, superne longe attenuata, 7 mm. longa.

South West Africa: Aus, Jan. 1928, *Neville S. Pillans* 6031. Fl. hort. Pillans Feb. 1928.

Aridaria paucandra L. Bol. forma.—Ramus 1 visus, ferus, brunneus, ad 8 mm. diam.; ramuli ad 4 mm., ultimi floriferi ad 1·5 mm. diam., internodiis ad 1·5 cm. longis, rubris; folia patentia vel demum leviter deflexa, lateraliter visa ovalia vel oblonge ovalia, novella subglobosa, supra levissime canaliculata, dorso rotundo, 1—1·6 cm. longa, prope medium ad 1 cm. lata, 7 mm. diam.; cyma 2-ternata, 5 cm. longa, 5·5 cm. diam.; flores nocturni; pedunculi 1·5—2·5 cm. longi; receptaculum 5 mm. longum, 6 mm. diam.; calycis tubus 5 mm. longus, segmentis exterioribus superne globosis; ad 6 mm. longis, ad 3 mm. diam., interioribus leviter carinatis, subacutis, 3—4 mm. longis, basi 3—5 mm. latis; petala 4-seriata, basi per 4 mm. coalita, interiora acuta, exteriora subobtusa, externe saturate rosea, ad 1·6 cm. longa, 1 mm. vel parum ultra lata; stamina ca. 5-seriata, ad 8 mm. longa; ovarium superne omnino superius, obtusum, fere ad 5 mm. elevatum; stigmata apud basim leviter patentia, gracilia, 7 mm. longa.

Cape Province: in dit. Vanrhynsdorp; "8 miles south of Nieuwerust," Sept. 1929, *N. S. Pillans* 6193. F. hort. Pillans No. 1929.

Aridaria barkerae L. Bol. sp. nov.—Rami 6 visi, feri, ad 24 cm. longi, internodiis 5—2·5 cm. longis, cuticula roseo grisea (columbina); folia ascendentia vel fere erecta, fere teretia, interdum subfalcata, obtusa, glauce viridia, 2—2·8 cm. longa, ad 5 mm. lata diametroque; cymae saepius 5-florae, pedunculis 1·4—3·5 cm. longis, late patentibus, floribus erectis vel leviter incurvis; receptaculum 5 mm. longum, 6 mm. diam., sat longe decurrente; calycis tubus 3 mm. longus, segmentis extimis primum e medio superne globosis adque 2 mm. diam., 7 mm. longis, basi 5—6 mm. latis, interioribus acutis, ample marginatis, 5 mm. longis, basi 4—6 mm. latis; petala ca. 4-seriata, basi per 4 mm. coalita, acuta vel obtusa, alba vel externe interdum pallide rosea, ad 1·5 cm. longa, ad 1 mm. lata; stamina ca. 5-seriata, ultra medium petalorum attingentia; ovarium fere inferius, lobis compressis obtusis, fere ad 3 mm. elevatis; stigmata prope basim levissime incrassata, longe attenuata, ad 7 mm. longa.

Cape Province: in dit. Ceres; Karoopoort, "ca. 2500 ft." Oct. 1932. *W. Barker*. Bolus Herbarium 20955.

The following collections of **Aridaria meyeri** L. Bol. are represented in the Bolus Herbarium: "14 miles S. of Steinkopf, Oct. 1930, *J. W. Mathews*. Bolus Herbarium 27825. Between Steinkopf and Eenriet, collected by *H. Herre* in 1946. Stellenbosch University Garden 11396.

Note.—The type specimens of all new species described in this paper are in the Bolus Herbarium, University of Cape Town.

(*To be continued*)

NOTES ON THE GENUS DELOSPERMA (MESEMBRIEAE)

M. Lavis

Delosperma kofleri Lavis sp. nov. (*Angustifolia*).—Planta erecta, glabra, 22 cm. diam.; rami primarii lignosi brunnei, ad 13 cm. longi, ad 2·5 mm. diam., internodiis 4—20 mm. longis; ramuli ascendentes vel fere patentes, superne interdum leviter incurvi, saepe pallidi, 2—10 cm. longi, 0·75—1·5 mm. diam. internodiis 4—18 mm. longis; folia ascendentia vel fere erecta, saepe subfalcata supra visa plana vel leviter concava, linearia, superne leviter angustata, acuta, dorso rotundo, viridia, lateraliter visa saepissime acuta, 4—15 mm. longa, medio 2—3 mm. lato diametroque; flores solitarii, ca. 1 cm. diam.; receptaculum obconicum, 3 mm. longum, 4 mm. diam.; pedunculi 3—4 mm. longi; sepala 5, abrupte acuta vel acuta, 3—5, vel extima 5—6 mm., interiora marginata, ad 3 mm., longa, basi 1—1·5 mm. lata; petala ca 2-seriata, infra medium inferne leviter angustata, apice rotundo, alba, 5—6 mm. longa, 1 mm. lata vel parum ultra; staminodia nulla; filamenta 3—4-seriata, epapillata alba, ad 3 mm. longa, antheris pollineque albidis; stigmata anguste subulata, 1·75 mm. longa cum cauda 0·75 mm. longa.

Basutoland: Roma Mission, *C. Kofler*. NBG 94/63. Fl. Nov. 1964.

Note:—The following 9 species are described from dried material and drawings in colour made from living specimens by Miss B. O. Carter.

Delosperma clavipes Lavis sp. nov. (*Angustifolia*).—Planta caespitosa, glabra, ramos ascendentes florentes ad 9·5 cm. elongatos emittens; folia primum ascendentia, deinde patentia demum omnino recurva, supra linearia, inferne superneque leviter angustata, canaliculata, dorso rotundo, ad 2·3 cm. longa, 3—4 mm. lata, 3 mm. diam.; flores solitarii vel 2-ternati, 2—5 cm. diam.; pedunculi 4—20 mm. longi; receptaculum clavatum, 5—8 mm. longum, 3—4 mm. diam.; sepala 5, inaequilonga, e prope basim superne leviter angustata, obtusa vel intima subacuta, 5—12 mm. longa, basi 2·5—4 mm. lata; petala 3-seriata, e bene supra medium angustata, interiora vel omnia emarginata, purpureo rosea, ad 1 cm. longa, ad 1 mm. lata; staminodia subpetaloidea rosea, apice leviter recurvo, ad 6 mm. longa; filamenta 3-seriata, pallide rosea, ad 5 mm. longa, intima in medio inconspicue papillata, antheris pollineque saturate luteis; glandulae distantes humiles, saturate viridibus; ovarium circa marginem planum, lobis profunde compressis, ad 2 mm. elevatis; stigmata inferne anguste subulata, longe attenuata, pallide lutea, 3·5 mm. longa, cauda subnulla.

ORANGE FREE STATE: Ficksburg, *E. E. Galpin*. NBG 2623/34. Fl. Sept. 1935.

Delosperma ficksbergense Lavis sp. nov. (*Angustifolia*).—Planta I visa, caule ad 3·5 mm. diam.; partes herbaceae sat conspicue papillatae, papillis setiferis, setis longis; rami decumbentes, ad 3 mm. diam., ultimi floriferi graciles, ad 20 cm. longi, internodiis saepius ad 1 cm. longis; folia ascendentia vel patentia, supra fere plana, obtusa, dorso rotundo, ad 2·2 cm. longa, ad 5 mm. lata vel ultra in umbrosis, 1—4 mm. diam.; flores 1—3-nati, 1·5—1·7 cm. diam.; pedunculi 2—4 mm., vel fructiferi ad 1·3 cm., longi; receptaculum obconicum papillatum, papillis deflexis, 3 mm. longum, 4 mm. diam.; sepala 5, obtusa, 3·5—5 mm. longa, basi ad 2 mm. lata; petala 3-seriata, parum infra apicem inferne angustata, alba, ad 8 mm. longa, 1 mm. vel parum ultra lata; staminodia acuminatissima alba, 5 mm. longa; filamenta 3—4-seriata, alba, seriebus interioribus 2 prope medium papillatis, antheris pollineque luteis; ovarii lobi stellate patentes, glandulas attingentes, obtuse compressi, ad 1·25 mm. elevati; stigmata 5, anguste subulata, ca. 2 mm. longa cum cauda 0·5 mm. longa.

Orange Free State: in dit. Ficksburg; "on the Farm Westbury, in rocks on summit of ridge, alt. 5,500 ft.; white and pink-flowered forms found within 50 yards of each other, the pink very rare." Oct. 1934, *E. E. Galpin*. Bolus Herb. 27820.

Delosperma knox-daviesii Lavis sp. nov. (*Angustifolia*).—Planta unica visa, glabra, laxe ramosa, ca. 9 cm. alta; rami 8·5—9 cm. longi; folia ascendentia vel patentia, demum recurvata, subteretia, minute papillata, supra plana, obtusa, prope apicem angustata, ad 3 cm. longa, 5—6 mm. lata, ad 4 mm. diam.; flores solitarii, ad 3·3 cm. diam.; pedunculi 1·6—2·5 cm. longi; receptaculum obconicum, 5 mm. longum, 7 mm. diam.; sepala 5, valde inaequalia, exteriora obtusa, 8—9 mm. longa, basi 3—5 mm. lata, interiora 3—4 mm. longa lataque; petala 4-seriata, seriebus 3 exterioribus emarginatis, e parum supra medium angustata, purpureo rosea, 1—5 cm. longa, ad 3 mm. lata, intima acuta, 8 mm. longa, 0·75 mm. lata; staminodia ad stamina adpressa eaque leviter excedentia; filamenta 2—3-seriata, intima parum infra medium papillata, ad 3—5 mm. longa, antheris pollineque pallide luteis; glandulae conspicuae, saturate virides, subdistantes; ovarii lobi stellate patentes, ad 1 mm. elevati, glandulas attingentes; stigmata 5, anguste subulata, longe attenuata, stamina leviter excedentia, ad 4 mm. longa, cauda brevissima.

TRANSVAAL: Johannesburg, *C. N. Knox-Davies*. NBG 2852/34. Fl. Maio. 1935.

Delosperma lootsbergense, Lavis sp. nov. (*Angustifolia*).—Rami 2 visi, pallide brunnei, 8·5—13·5 cm. longi, 3 mm. diam., internodiis 1—2·5 cm. longis; partes herbaceae virides; folia erecta vel ascendentia, demum patentia, dorso rotundo, lateraliter visa obtusa, prope apicem leviter angustata, papillata, papillis setiferis, setis ascendentibus, 1·2—2·2 cm. longa, 2—3 mm. diam.; flores ad 2·5 cm. diam.; pedunculi 1·1—2 cm. longi; receptaculum obconicum, medio leviter constricto, 1 cm. longum, 8 mm. diam.; sepala 5, semiteretia, 4—6 mm. longa, interiora marginata; petala 3-seriata supra medium inferne leviter angustata, obtusa, roseo purpurea 1—1·3 cm. longa, 1—1·5 mm. lata; staminodia erecta acuminata rosea, stamina subae-quantia, 5 mm. longa; filamenta 3-seriata, ad 5 mm. longa, intima basi obscure papillata, antheris luteis; glandulae inconspicuae crenulatae; ovarii lobi stellate patentes, obtuse compressi, glandulas attingentes; stigmata 5, subulata, 2·5 mm. longa cum cauda 1·25 mm. longa.

Cape Province: in dit. Middelburg; Lootsberg, *H. H. Bolus* 17. Fl. in hort. Sept. 1927. Bolus Herb. 27821.

Delosperma cloeteae Lavis sp. nov. (*Angustifolia*).—Rami 7 visi, glabri, laxe ramulosi, flexuosi, ad 18 cm. longi, ad 4 mm. diam., internodiis 1—3·5 cm. longis; ramuli ultimi floriferi 2—5 cm. longi; folia erecta vel ascendentia vel rare patentia, supra linearia acuminata, lateraliter visa prope apicem angustata, dorso subobtuso, viridia, 2—4·2 cm. longa, 4 mm. lata diametroque, matura brevissime vaginata; flores 1·8 cm. diam., singuli vel 3-nati vel demum 2-ternati cymamque densam formantes; receptaculum saepius semiglobosum, ca. 4·5 mm. longum diametroque; sepala 5, acuta vel acuminata, valde inaequalia, extima ad 1·7 cm., cum aetate ad 2 cm., accrescentia, basi 4 mm. lata, interiora marginata, 4—6 mm. longa, basi 2—4·5 mm. lata; petala 2-seriata, e supra medium inferne angustata, apice rotundo, roseo purpurea, ad 8 mm. longa, ad 1·5 mm. lata; staminodia petaloidea, ad stamina adpressa eaque leviter superantia, rosea, 3·5—4 mm. longa; filamenta 3-seriata, rosea, 2—3 mm. longa, in medio vel parum supra papillata, antheris pollineque luteis; glandulae approximatae crenulatae; ovarii lobi erecti, obtuse compressi, glandulas non attingentes; stigmata 5, subulata, 1·5 mm. longa, cauda brevissima.

Cape Province: in dit. Fort Beaufort; Kroomie, *Miss F. Cloete*. NBG 1654/29. Fl. Jan. 1933.

Delosperma truteri Lavis sp. nov. (*Planifolia—Glabra*).—Planta glaberrima; rami decumbentes lignosi, ad 17 cm. longi, internodiis 1—4·5 cm. longis, ad 3 mm. diam., vel plantae cultae compactae vel interdum caespitosae; folia ascendentia vel patentia vel reflexa, supra ovalia vel ovata vel oblonga, acuta, levia polita, viridia vel interdum sordide purpurea, 1·2—2·5 cm. longa, 7—13 mm. lata, ad 8 mm. diam.; flores solitarii, subsessiles vel pedunculi ad 5 mm., fructiferi ad 1·5 cm., longi; receptaculum obconicum, ad 4 mm. longum, ad 7 mm. diam.; sepala 5 extima folia simulantia, 8—10 mm. longa, ad 4 mm. diam., interiora mucronata marginata, 2—4 mm. longa, vel in flore altero extima 8 mm., interiora 4—6 mm., longa; petala ca. 3-seriata, e parum infra medium inferne angustata, obtusa alba nitentia, 4—15 mm. longa, ad 1·75 mm. lata; staminodia ad stamina adpressa eaque leviter excedentia; filamenta 3-seriata, epapillata, antheris pollineque primum luteis; glandulae subdistantes crenulatae; ovarii lobi erecti, obtuse compressi, ad 2 mm. elevati; stigmata 5, anguste subulata, ad 2·5 mm. longa cum cauda 0·75 mm. longa; capsula infra obconica 5—6 mm. longa, 7 mm., expansa, 12 mm., diam., supra ad 3 mm. elevata, suturis compressis.

Cape Province: in dit. Somerset East; "Oudekraal (farm adjoining Brakfontein), growing on krantzes in the foothills of the Zuurberg," *J. Truter, P. A. B. van Breda* 1707. Fl. Veld Reserve, Worcester, Jun. 1962 et 1966.

Delosperma deleeuwiae Lavis sp. nov. (*Planifolia—Glabra*).—Plantae cultae 3 visae, caespitosae, ad 4 cm. diam.; rami primarii ad 3·8 cm. longi, ad 6 mm. diam.; folia ascendentia vel demum patentia, supra oblonga plana, prope basim leviter angustata, concava, dorso rotundo, papillata, papillis setiferis, setis papillas aequantibus, 1·2—2·2 cm. longa, medio 1·1 cm. lato et 5 mm. diam.; flores singuli, 4 cm. diam., pedunculo hispido, ad 5 mm. longo; receptaculum subovale hispidum, 7 mm. longum, 5 mm. diam.; sepala 5, subaequilonga obtusa, ad 6 mm. longa, basi ad 4 mm. lata, vel extima ad 8 mm. longa, 3—4 mm. lata; petala ca. 7—8-seriata, vel intima staminodia simulantia, sed non ad stamina adpressa, acuta, pallide rosea, 1—2 cm. longa, 1 mm. lata, exteriora e parum supra medium inferne angustata, obtusa vel emarginata, purpureo rosea, ad 2 cm. longa, ad 2 mm. lata; filamenta 3—4-seriata, 2—4 mm. longa, intima infra medium papillata, antheris pollineque luteis; glandulae approximatae inconspicuae brunneae; ovarium supra concavum; stigmata 5, anguste subulata, 2 mm. longa, brevissime caudata.

Orange Free State: Clarens; *Mrs. de Leeuw*. NBG 1882/26. Fl. Jan.—Mart. 1932—1933.

Delosperma suttoniae Lavis sp. nov. (*Planifolia—Glabra*).—Plantae florentes cultae 5 visae, 2—4·2 cm. altae, vel demum ramo ad 8 cm. longo producto; radix tuberosa globosa, 3 cm. diam., prope apicem tubercula crebra globosa, ad 7 mm. diam., radicula fibrosa ornata, ferens; rami primarii ad 6 mm. diam.; folia patentia crebra variabilia, lanceolata acuta vel acuminata, aut ovata obtusa vel rarissime oblonga, prope basim apicemque leviter angustata, glabra, minute punctata, sordide viridia, carina ad lineam reducta, 3—6 cm. longa, 1—1·7 cm. lata; flores sessiles vel brevissime pedunculati, pedunculis hirsutis, 4—5 cm. diam.; receptaculum obconicum, parce hispidum, setis patentibus, 7 mm. longum, 12 mm. diam., prope basim apicemque leviter angustata; sepala

5—7, acuta vel obtusa, punctata, extima 8—10 mm. longa, basi 3—4 mm. lata, interiora marginata, 5—6 mm. longa, basi 3—4 mm. lata; petala 3-seriata, e supra medium inferne angustata, subobtusa vel emarginata, rosea, exteriora inferne saturatiore vittata, ad 2·2 cm. longa, ad 2 mm. lata; staminodia inferne ad stamina adpressa eaque bene excedentia, superne valde recurva; filamenta 3-seriata, ad 7 mm. longa, intima prope medium papillata, antheris pollineque pallidis; glandulae 5—7, conspicuae approximatae crenulatae; ovarii lobi stellate patentes, glandulas attingentes, obtuse compressi, ad 1·5 elevati; stigmata 5—7, subulata, ad apicem dense papillata; capsula infra semiglobosa hispida, 3—5 mm. longa, 7 mm., expansa, 15 mm., diam., supra per 5 mm. elevata, suturis erectis, valde compressis.

Natal: Ladysmith. "Altitude ca. 3,824 ft.", *Miss Sutton*. NBG 2676/30. Fl. Mart. 1931.

Delosperma peersii Lavis sp. nov. (*Cymosa—Frutescentia*).—Planta 1 visa, sat rigida, glabra, ca. 24 cm. alta; rami ramulique saepius ascendentes, superne suberecti, prope apicem rubri, ad 17·5 cm. longi, internodiis 2—10 mm. longis, 1·5—5 mm. diam., vel ultimi floriferi stricti, 5·5 cm. longi, internodiis 4—8 mm. longis; folia ascendentia vel fere patentia, supra plana, dorso rotundo, minute mucronata, mucrone leviter recurvo, rubro, 5—14 mm. longa, ad 3 mm. lata, 2—4 mm. diam.; flores 1—3-nati, 2 cm. diam.; pedunculi 5—8 mm. longi; receptaculum globose obconicum, ad 5 mm. longum diametroque, prope medium leviter constrictum; sepala 5, extima obtusa, fere ad 5 mm. longa, basi 2 mm. lata, interiora acuta vel subacuminata, late marginata, 1·5—2 mm. longi, basi ad 1·5 mm. lata; petala 1—2-seriata, bene e supra medium inferne angustata, apice rotundo, rosea, prope basim pallida, 9 mm. longa, 1 mm. lata vel parum ultra; staminodia prope apicem leviter recurva, stamina aequantia; stamina 2-seriata, interiora parum infra medium papillata; glandulae arcte approximatae; ovarii lobi erecti, vix compressi, apice rotundo, fere ad 1·5 mm. elevati; stigmata 5, anguste subulata, longe attenuata, 2—5 mm. longa; capsulae 2, senectissimae visae, infra obconicae, 4—5 mm. longae, 5 mm., expansae, 8 mm. diam., loculis leviter alatis.

Cape Province: in dit. Willowmore; Vondeling, *V. S. Peers*. NBG 971/30 Fl. Apr. 1933.

NOTE:—The type specimens of all new species described in this paper are in the Bolus Herbarium, University of Cape Town.

(*To be continued*)

ANATOMIE VAN DIE STINGELS VAN *PROTEA REPENS* (L.) L. EN *LEUCADENDRON ADSCENDENS* R. BR.

II. ANATOMIE VAN DIE STINGELS*

CARINA VISSER

(*Departement van Plantkunde, Universiteit van Kaapstad*)

ABSTRACT

The anatomy and histology of the stems of *Protea repens* (L.) L. non Thunb. and *Leucadendron adscendens* R. Br. were investigated and compared. It was found that the anatomy and histology of the two species agree to a large extent.

The study comprised an anatomical investigation of the structure of the young stem with primary growth, the older stem with secondary growth and of the considerably older stem. The young stems have closely spaced primary vascular bundles with narrow interfascicular regions. The secondary vascular tissues form a continuous cylinder. The wood is diffuse porous, and indistinct growth rings can be recognized in it. Uni- and multiseriate vascular rays occur, the latter opposite the interfascicular regions.

The structure of the nodes was also examined. Trilacunar nodes occur and three leaf traces diverge into each leaf.

Special attention was given to the histology of the following tissues: periderm, phloem and xylem. The phellogen originates in both the epidermis and the outer cell layer of the cortex, and remains active for many years, but only a thin layer of phellem is present. The phloem consists of sieve tubes with compound sieve plates, companion cells and phloem parenchyma. The xylem consists of vessels with simple perforation plates, xylem parenchyma, libriform fibres and fibre-tracheids.

INLEIDING

Daar is min navorsing oor die anatomie van die vegetatiewe organe van die Proteaceae gedoen, en wat wel gedoen is, is hoofsaaklik van Australiese soorte. Engler (1893) gee 'n kort opsomming van wat destyds reeds bekend was oor die algemene anatomiese kenmerke van die jong stingels en blare van die Proteaceae. Die werk van Tassi (1898) bevat data oor die blare en stingels van 'n hele aantal genera o.a. van *Protea* en *Leucadendron*. In 1899 gee Solereder 'n baie kort opsomming van die anatomiese kenmerke van die Proteaceae, wat gebaseer is op sy eie navorsing op 'n aantal genera, sowel as op werke van sy voorgangers.

Die grootste stuk werk oor die stingelanatomie van die familie, wat in die

---

[*] Tweede deel van 'n verkorte weergawe van 'n verhandeling vir die verkryging van die M.Sc.-graad in die Plantkunde aan die Universiteit van Stellenbosch, Februarie 1964.

beskikbare literatuur gevind kon word, is dié van Chattaway (1948a). Sy het die houtanatomie van meer as 90 spesies van die Proteaceae, uit 26 genera (waaronder ook Suid-Afrikaanse genera), ondersoek. In 'n verdere artikel (1948b) bespreek sy die voorkoms van vaatweefsel in die vaatstrale van *Banksia.* Metcalfe en Chalk (1950) gee 'n breedvoerige opsomming van die anatomiese kenmerke van die blare, jong stingels en die hout van die Proteaceae. In 'n ondersoek oor die sitotaksonomie van die Proteaceae gee Rao (1957) kortliks sy mening oor die houtanatomie van die familie.

In die bg. beskikbare literatuur is dus baie min gegewens te vind oor die anatomie en histologie van die stingels van die Suid-Afrikaanse Proteaceae. In die huidige ondersoek is 'n poging aangewend om leemtes in hierdie verband aan te vul.

MATERIAAL EN METODES

Soos in die vorige ondersoek (Visser, 1965) is stingels van *Protea repens* (L.) L. non Thunb. (P. mellifera Thunb.) en *Leucadendron adscendens* R. Br. uit die Jan Marais-park in Stellenbosch vir ondersoek gebruik. Versamelings is, soos reeds vermeld, dwarsdeur die jaar gemaak. Stingels met primêre groei alleen, die begin van sekondêre groei, een- en driejarige sekondêre groei, asook stamme van 12 en 16 jaar oud, is ondersoek d.m.v. dwars- en lengtesneë en maserasie.

Dieselfde metode as in die vorige ondersoek is aangewend vir die maak van permanente preparate, behalwe dat safranien en vaste groen algemeen as kleurstowwe gebruik is. Waar moeilikheid ondervind is om harde materiaal met die rotasiemikrotoom te sny, is die wasblokkies met die ingebedde materiaal vir 'n paar dae in gedistilleerde water geplaas (Sass, 1958). Van die verhoute stingels is ook handmikrotoomsneë met 'n dikte van 10—20μ gemaak.

Jeffrey se maserasiemetode, met gelyke dele van 10% chroomsuur en 10% salpetersuur is gebruik (Sass, 1958). Vir die kleuring van tannien is kaliumdichromaat gebruik (Strasburger en Hillhouse, 1900). Toetse vir die teenwoordigheid van kallose is uitgevoer met anilienblou (McLean en Ivimey Cook, 1941) of met 'n versadigde oplossing van resoblou (lakmoïed) waarby 'n spoor gekonsentreerde ammoniak gevoeg is.

Die figure is geteken met 'n Zeiss Promar-tekenapparaat, of 'n Zeiss camera lucida.

ONDERSOEK

1. Uitwendige stingelmorfologie

Soos reeds in die vorige ondersoek vermeld, gee die meeste eindknoppe oorsprong aan bloeiwyses, terwyl 'n aantal okselknoppe daaronder vir stingelverlenging en vertakking verantwoordelik is. Stingelvertakking geskied dus simpodiaal, en hierdie feit is gebruik om die ouderdom van stingels uitwendig bepaal. Daar is aangeneem dat die stingelgedeelte tussen twee opmekaarvolgende vertakkingsplekke die groei van een jaar is.

Okselknoppe word in een groeiseisoen gevorm en groei op die gouste die volgende groeiseisoen uit. Hulle is altyd eers verantwoordelik vir stingelverlenging en nooit dadelik vir die vorming van bloeiwyses nie. Die wat nie uitgroei nie, bly vir 'n onbepaalde tyd rustend.

2. **Primêre bou van die jong stingel** (figure 1—2)

Epidermis. Die jong stingels van *P. repens* en *L. adscendens* word aan die buitekant afgesluit deur 'n eenlagige epidermis met 'n dun tot redelik dik kutikula. Geen epidermale hare kom voor nie. Ingesinkte huidmondjies is hier en daar aanwesig.

Fellogeen. By *P. repens* ontstaan die fellogeen reeds vóór sekondêre verdikking, gedurende die maande wanneer die groeipunte rustend is. By *L.*

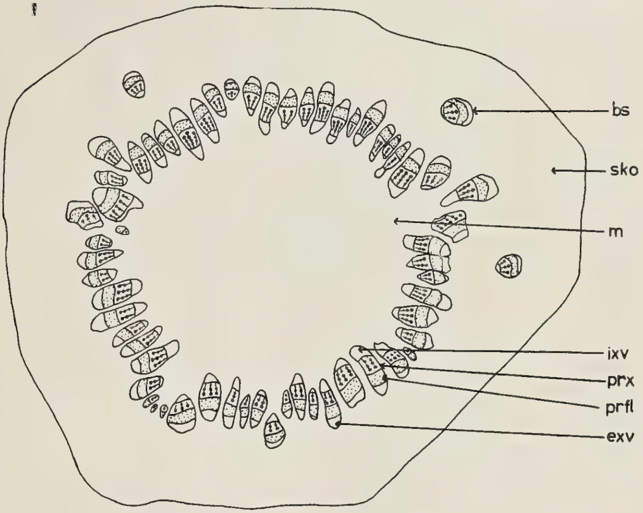


FIG. 1.
Diagram van 'n dwarssnee van 'n jong *Protea repens*-stingel met primêre bou × 13; bs, blaarspoor; exv, ekstraxilêre vesels; ixv, xilêre vesels; m, murg; prfl, primêre floëem; prx, primêre xileem; sko, skors.

2

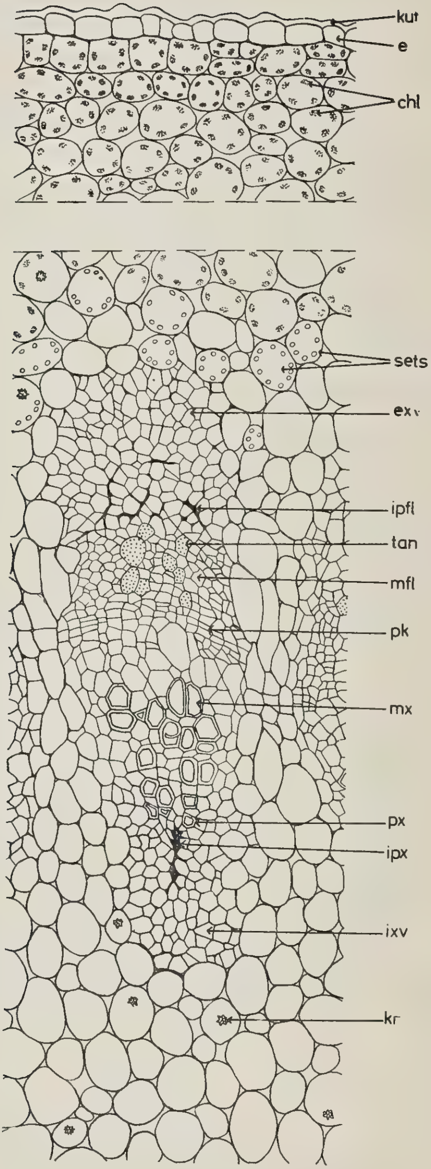


FIG. 2.
Detail van 'n sektor van fig. 1, × 140; chl, chloroplaste; e, epidermis; exv, ekstraxilêre vesels; ipfl, deels geoblitereerde protofloëem; ipx, geoblitereerde protoxileem; ixv, xilêre vesels; kr, kristal; kut, kutikula; mfl, metafloëem; mx, metaxileem; pk, prokambium; px, protoxileem; sets, setmeelskede; tan, tannien.

adscendens word geen fellogeen by die jong stingels aangetref nie, maar eers later.

Die fellogeen ontstaan by beide soorte meesal uit die buitenste lagie skorsparenchiemselle, maar soms uit die epidermis. Dit kan selfs in één stingel op sommige plekke uit die epidermis en op ander plekke uit die skors ontstaan. Dit is egter monogeen, d.w.s. ontstaan uit één sellaag. Dit ontstaan nie gelyktydig rondom die stingel nie. Die betrokke skors- of epidermisselle ondergaan 'n tangensiale deling om die fellogeen te vorm, en deur herhaaldelike tangensiale delings van lg. word die felleemselle in radiale rye na buite gevorm. Op hierdie stadium geskied nog geen antiklinale delings nie.

Die jong felleemselle is aanvanklik lewendig, dunwandig en bevat tannien.

Skors. Die skors van *P. repens* varieer van 490—930μ in breedte. By die manlike stingels van *L. adscendens* is dit 110—195μ en by die vroulike stingels 290—390μ breed.

Die skors bestaan uit groot, ronde, dunwandige parenchiemselle, met klein tot taamlike groot intersellulêre ruimtes. Talryke chloroplaste kom veral in die buitenste deel daarvan voor. By *P. repens* kom stervormige tot kubiese kalsiumoksalaatkristalle voor. By *L. adscendens* word oliedruppels in die skors aangetref. Talryke steenselle word verspreid, enkeld of in groepe, by beide soorte aangetref. Die steenselle verskil in grootte en vorm, en besit dik,verhoute wande waarin apposisielae en eenvoudige stippels met eenvoudige of vertakte stippelkanale te onderskei is.

Geen egte endodermis met bandjies van Caspary kom voor nie. By *P. repens* word in die paar lae skorsselle net buite die vaatbundels setmeelkorrels aangetref in 'n onreëlmatige, onderbroke laag. Hierdie laag kan as setmeelskede beskou word. By *L. adscendens* kom setmeelkorrels versprei deur die skors voor.

Die vaatbundels wat in die skors lê, is blaarspore. Hulle is kollateraal en lê met hul xileem en floëem radiaal of dikwels skeef geplaas.

Murg. Die murg varieer in deursnee van ongeveer 1·1—2·6 mm. by *P. repens;* by *L. adscendens* varieer dit van 680—780μ by vroulike en 490—585μ by manlike stingels.

Dit bestaan uit groot, ronde, lewende, tannienbevattende parenchiemselle met intersellulêre ruimtes. Die selwande is aanvanklik onverhout, maar verdik en verhout later effens. By *P. repens* word kalsiumoksalaatkristalle aangetref, en by *L. adscendens* kom setmeelkorrels en enkele oliedruppels versprei deur die murg voor.

Vaatbundels. Talryke vaatbundels van verskillende groottes lê dig teenmekaar in 'n onreëlmatige kring, met besonder smal murgstrale (een tot drie selle wyd) tussen die bundels.

Buite elke vaatbundel word 'n groep ekstraxilêre vesels aangetref. Hulle ontstaan as volg: wanneer die protofloëemsifbuise hul funksie verloor, vergroot die aangrensende jong parenchiemselle effens en druk die sifbuise inmekaar. Gedurende die maande van aktiewe stingelverlenging is hierdie parenchiemselle lewend, dunwandig en onverhout. In die maande van rus verhout en verdik hul selwande en differensieer hulle tot groepe vesels. Hulle kan as primêre floëemvesels beskou word.

Die metafloëem vorm die funksionele deel van die primêre floëem, aangesien die protofloëem baie gou vernietig word. Groot sifbuise, begeleidende selle en floëemparenchiem is te onderskei. Saamgestelde sifplate met kallose kom voor tussen die sifbuissegmente. In enkele floëemelemente, veral die ouer floëemparenchiem, kom tannien voor.

Aangesien primêre groei nog hier plaasvind, moet van 'n prokambium of van prokambiale stroke gepraat word. Dit is in ooreenstemming met Esau (1943) se interpretasie. Die prokambium is 'n aantal sellae dik in dwarsnee, en differensieer na weerskante geleidelik tot primêre xileem en floëem (fig. 2). Wanneer stingelverlenging aktief is, geskied seldeling vinnig en differensiasie raak agter, sodat breë stroke onvolwasse xileem- en floëemelemente weerskante van die prokambium voorkom. Gedurende die russtadium vind seldeling stadig of glad nie plaas nie, differensiasie hou tred daarmee, en volwasse floëem- en xileemelemente kom dig teen die prokambium voor.

In 'n dwarssnee is die prokambiumselle dunwandige, reghoekige, afgeplatte, radiaal gerangskikte selle. Die radiale wande is effens dikker as die tangensiale wande as gevolg van herhaaldelike tangensiale seldelings. In 'n lengtesnee is die selle verleng, smal, dunwandig, met skerp punte, en eenders.

In die protoxileem word tracheale elemente met spiralige wandverdikkings en parenchiemselle aangetref, maar geen vesels nie. In die metaxileem kom ook leer-, net- en selfs stippeltracheale elemente (tracheïede en vate) voor. Laasgenoemde elemente is 20—25μ in deursnee, met segmente 390—540μ lank. Eenvoudige, skuinsgeplaasde perforasieplate kom in die vate voor. Die oorgang van proto- na metaxileem is geleidelik.

Aan die binnekante van die vaatbundels word klein groepies xilêre vesels aangetref. Hulle ontstaan uit jong parenchiemselle wat vergroot en waarvan die wande verdik en verhout. Die sagte dele van die tracheale elemente van die protoxileem word tussen hulle inmekaar gedruk, maar die spiraalverdikkings van die tracheale elemente is nog tussen die vesels te onderskei.

3. **Begin van sekondêre groei en die bou van een en drie jaar oue stingels** (figure 3—11, 13—16)

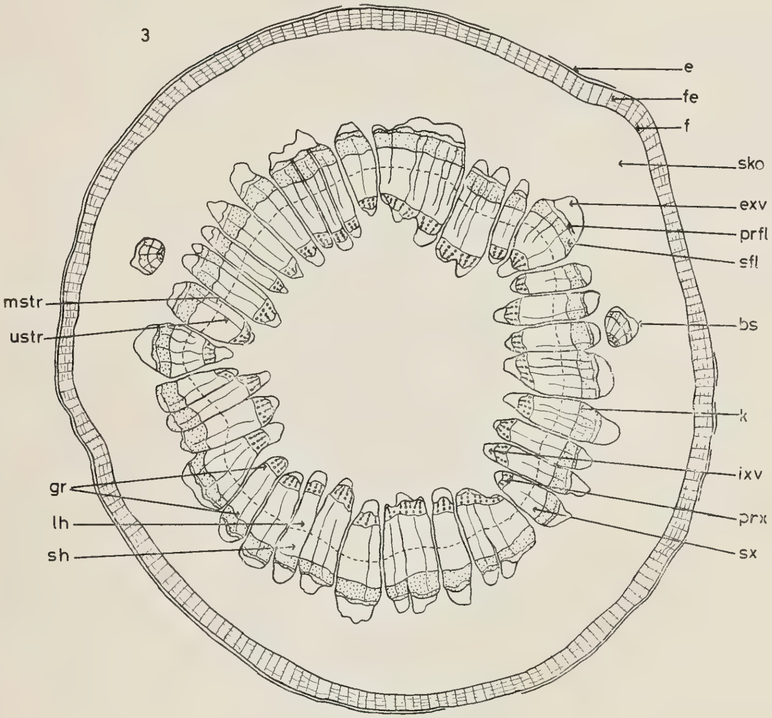


FIG. 3.

Diagram van 'n dwarssnee van 'n eenjarige *Protea repens*-stingel met sekondêre verdikking, × 16; bs, blaarspoor; e, epidermis; exv, ekstraxilêre vesels; f, fellogeen; fe, felleem; gr, groeiring; ixv, xilêre vesels; k, kambium; lh, lentehout; mstr, multiseriale vaatstraal; prfl, primêre floëem; prx, primêre xileem; sfl, sekondêre floëem; sh, somerhout; sko, skors; sx, sekondêre xileem; ustr, uniseriale vaatstraal.

Epidermis en periderm. By eenjarige stingels van *P. repens* word reeds 'n kurklagie van vier tot ses sellae breed (78—100μ) aangetref. Aan die buitekant van die kurklagie is die epidermis met 'n dik kutikula nog te onderskei. Namate die stingel in omvang toeneem, skeur die epidermis. By die driejarige stingel is dit nog plek-plek te onderskei.

Die periderm bestaan uit fellogeen en felleem, maar geen felloderm nie.

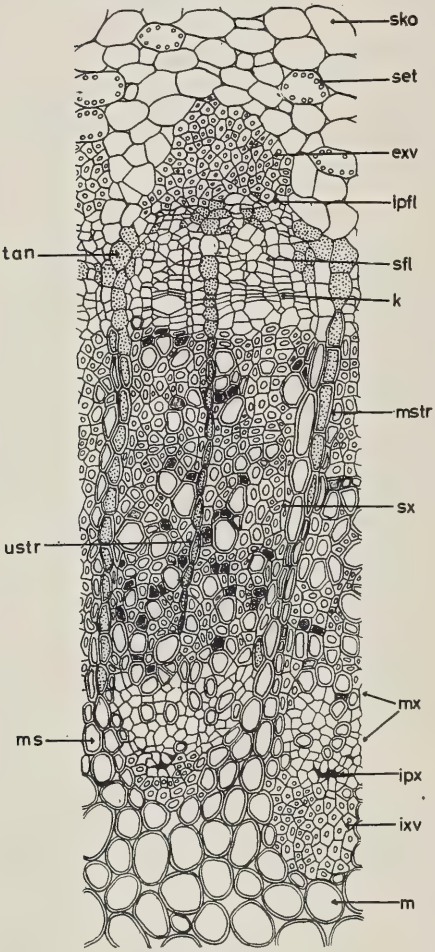
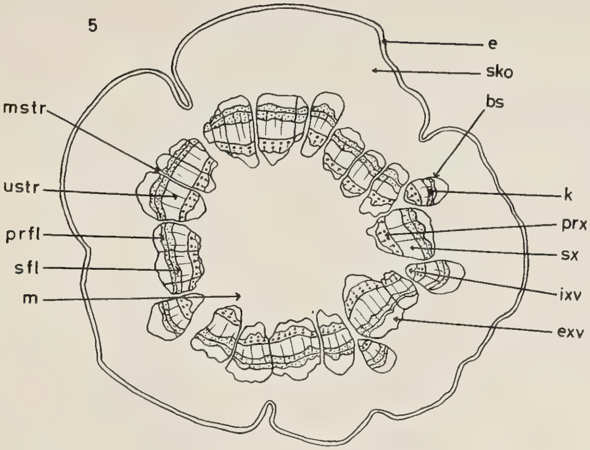


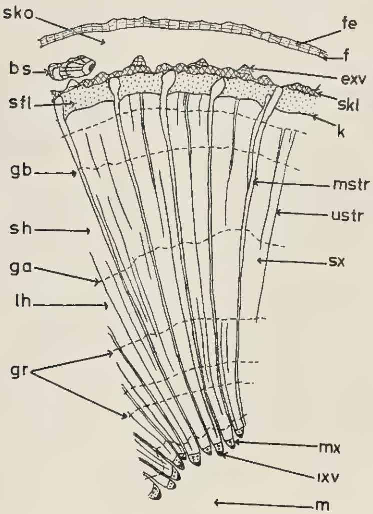
FIG. 4.

Detail van 'n sektor uit fig. 3, × 144; exv, ekstraxilêre vesels; ipfl, geoblitereerde protofloëem; ipx, geoblitereerde protoxileem; ixv, xilêre vesels; k, kambium; m, murg; ms, murgstraal; mstr, multiseriale vaatstraal; mx, metaxileem; set, setmeelkorrels; sfl, sekondêre floëem; sko, skors; sx, sekondêre xileem; tan, tannien; ustr, uniseriale vaatstraal.

5



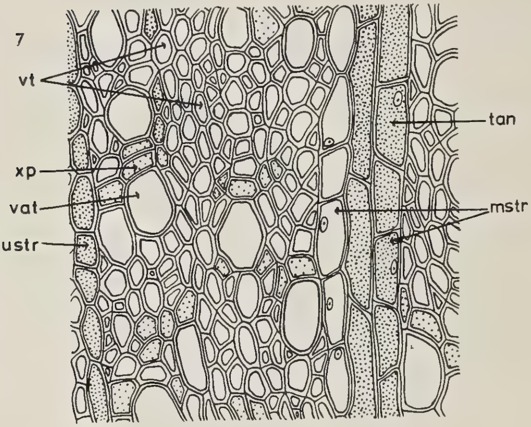
6



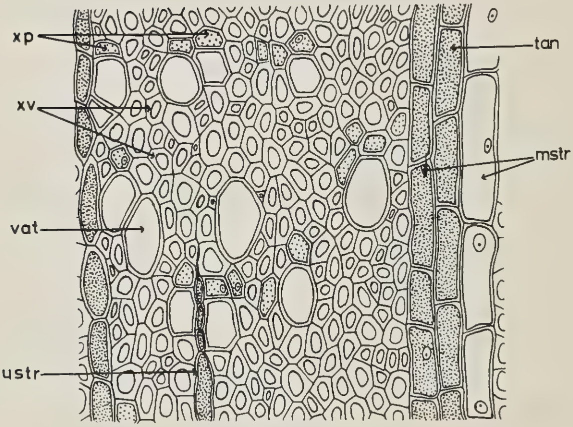
Fige. 5, 6.

Diagramme van sekondêre groei by stingels in dwarssnee: fig. 5, begin van sekondêre groei by *Leucadendron adscendens*, × 20; fig. 6, vier jaar oue *Protea repens*-stingel, × 9·5; bs, blaarspoor; e, epidermis; exv, ekstraxilêre vesels; f, fellogeen; fe, felleem; ga, grens tussen lente- en somerhout; gb, grens tussen twee groeiringe; gr, groeiring; ixv, xilêre vesels; k, kambium; lh, lentehout; m, murg; mstr, multiseriale vaatstraal; mx, metaxileem; prfl, primêre floëem; prx, primêre xileem; sfl, sekondêre floëem; sh, somerhout; skl, sklerenchiemlaag; sko, skors; sx, sekondêre xileem; ustr, uniseriale vaatstraal.

7



8



FIGE. 7, 8.
Details van hout uit fig. 6, × 255: fig. 7, lentehout; fig. 8, somerhout; mstr, multiseriale vaatstraal; tan, tannien; ustr, uniseriale vaatstraal; vat, xileemvat; vt, veseltracheïed; xp, xileemparenchiem; xv, xileemvesels.

Die kurkselle is nog lewend, dunwandig, met die wande oral ewe dik, en is sonder intersellulêre ruimtes. In 'n dwarssnee is hul reghoekig of vierkantig, maar is onreëlmatig of poligonaal in 'n tangensiale lengtesnee. Die meeste felleem- en fellogeenselle bevat tannien, ander vertoon leeg. Die wande is verkurk, maar bevat geen lignien nie. Aparte wandlae kon nie onderskei word nie.

By die drie jaar oue stingel van *P. repens* is die kurk ongeveer 100—120μ (ses tot nege sellae) dik. Die bou daarvan is nes by jonger stingels, behalwe dat die buitenste paar lae selle direk onder die epidermis platgedruk en dood is.

Eenjarige stingels van *L. adscendens* word slegs deur 'n epidermis en kutikula afgesluit, aangesien kurk eers in tweejarige stingels gevorm word. By die driejarige stingel is die kurk reeds ongeveer 80—195μ (agt tot twaalf sellae) dik, met selle soos by *P. repens*.

Lentiselle kom voor as ronde of horisontale selmassas wat effens bo die stingeloppervlakte verhef is deur 'n opening in die kurk. Die grootte daarvan varieer van skaars sigbaar met die blote oog tot ongeveer drie tot vier mm deursnee in tangensiale rigting. Hul kom enkeld voor of in groepies wat 'n vertikale ry onderkant die blaarsteel vorm, en is nie baie volop nie.

Die lentisel (fig. 11) bestaan uit 'n massa groterige, taamlik ronde tannienryke vulselle met dun, effens verkurkte selwande en klein intersellulêre ruimtes tussenin. Onder die massa vulselle is 'n paar lagies gewone kurkselle dig opmekaar, wat 'n sluitvlies vorm. Die sluitvlies is dwarsdeur die jaar te onderskei, en is soms net twee lae en ander kere ses of meer sellae breed.

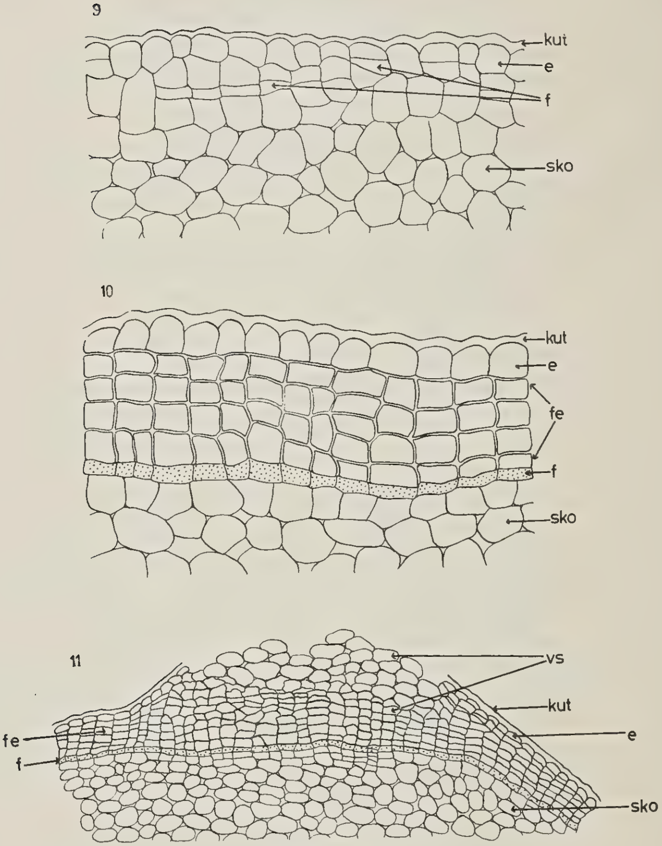
Hierdie tipe lentisel stem naasteby ooreen met Wutz (1955) se Salix-tipe. Volgens Wutz is dit die eenvoudigste tipe lentisel by Angiospermae, en besit dit geen histochemiese differensiasie in die selwande van die vulweefsel nie, aangesien al die vulselle verkurkte wande het.

Skors. By die ouer stingels neem die breedte van die skors geleidelik af, tot ongeveer 290—390μ by die driejarige stingels van *P. repens* en 190—290μ by dié van *L. adscendens*.

Die bou van die skors stem ooreen met dié van jong stingels. Die skorsparenchiemselle vertoon hier egter meer ovaalvormig in tangensiale rigting, a.g.v. tangensiale selstrekking. Plek-plek het radiale seldelings plaasgevind, Dilatasie van die skors geskied dus deur tangensiale strekking en radiale deling van die selle.

Murg. Die murg toon by die driejarige stingels 'n effens kleiner deursnee as by die jonger stingels, nl. 0·9—1·95 mm by *P. repens* en 560—780μ by *L. adscendens*. Die murgparenchiemselwande is by die driejarige stingels verhout.

Vaatweefsel en sekondêre verdikking. Nieteenstaande die sekondêre verdikking, is die afsonderlike vaatbundels nog te herken, veral deur die ligging



FIGE. 9—11.

Dwarsneë deur oppervlakkige deel van stingels van *Protea repens*: fig. 9, ontwikkeling van die fellogeen, × 140; fig. 10, jong kurk, × 140; fig. 11, lentisel, × 45; e, epidermis; f, fellogeen; fe, felleem; kut, kutikula; sko, skors; vs, vulselle.

van die groepe ekstraxilêre en xilêre vesels, asook deurdat die vaatstrale teenoor die murgstrale gevorm word.

Baie meer sekondêre xileem as floëem is gevorm by die driejarige stingels, nl. 'n breedte van 145—215μ floëem teenoor 2·0—3·7 mm xileem by *P. repens*, en 100—145μ floëem teenoor 1·8—2·4 mm xileem by *L. adscendens*.

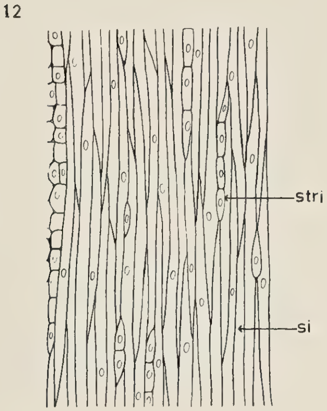


FIG. 12.

Tangensiale lengtesnee deur die kambium van *Protea repens*, × 100; si, spilvormige inisiales; stri, straalinisiales.

(a) *Floëem.* By die eenjarige stingel van *P. repens* word die groepe ekstraxilêre vesels soos voorheen aangetref. By die driejarige stingel kom buite die funksionerende sekondêre floëem en binne die ekstraxilêre vesels 'n onreëlmatige, min of meer aaneenlopende sklerenchiemlaag van ongeveer 115—195μ breed voor (fig. 6). Vesels, steenselle en oorgangsvorme tussen hulle word hierin aangetref (fig. 15). Dit ontstaan waarskynlik uit sekondêre floëem wat nie meer funksioneer nie.

'n Onreëlmatige sklerenchiemlagie kom by *L. adscendens* reeds by die eenjarige stingel voor.

Net binne die groepe vesels kom by eenjarige stingels nog bietjie primêre floëem voor, met elemente kleiner as dié van die sekondêre floëem en met baie min radiale rangskikking van die selle. Vaatstrale ontbreek daarin.

In die sekondêre floëem is sifbuise, begeleidende selle en floëemparenchiem aanwesig. Saamgestelde sifplate kom op die skuinsgeplaasde eindwande voor (figure 13—14), terwyl sifareas op die lengtewande te onderskei is. Kallose kom op die sifplate van alle ouer sifbuise voor in al die jaargetye. Vaatstrale is hier aanwesig.

By die driejarige stingels is geen primêre floëem meer te onderskei nie.

In die ouer, nie meer funksionerende deel van die sekondêre floëem het die elemente dikker wande en is hulle ryk aan tannien. Gedeeltelik geoblitereerde floëemelemente kom hier voor.

(b) *Kambium.* Die kambiale gordel bestaan uit drie tot vier lagies afgeplatte, reghoekige, dunwandige selle waarvan die radiale wande effens dikker is as die tangensiale wande a.g.v. herhaaldelike tangensiale seldelings. Spilvormige inisiales en straalinisiales kom voor, wat respektiewelik die aksiale elemente en die vaatstrale van die sekondêre vaatweefsel vorm. Die kambiumderivate toon 'n reëlmatige radiale rangskikking en differensieer aan weerskante geleidelik tot sekondêre xileem- en floëem.

In 'n dwarssnee verskil die spilvormige inisiales en straalinisiales min, maar in 'n tangensiale lengtesnee (fig. 12) is die verskil opvallend. Die spilvormige inisiales is lang, smal selle (330—390μ lank by *P. repens*) met skerp punte. Hulle lê nie in horisontale reekse nie, en die kambium is dus ongeordend. Die straalinisiales is kort, isodiametriese of effens verlengde selle wat in groepe, die hoogte en wydte van die vaatstrale, voorkom.

In die groeiseisoen vind seldeling in die kambium vinniger as differensiasie plaas, en stroke onvolwasse sekondêre xileem- en floëemelemente kom weerskante van die kambiale gordel voor (fig. 4). In die onaktiewe tydperk vind seldeling stadig of glad nie plaas nie, sodat die differensiasie die agterstand inhaal; volwasse elemente word dig teen die kambiale gordel aangetref.

(c) *Xileem* (figure 7, 8, 16). In die sekondêre xileem is by die eenjarige stingels één groeiring te onderskei, sonder 'n skerp grens tussen die lente- en somerhout.

Stingels wat drie jaar oud is, te oordeel na uitwendige kenmerke, toon in sommige gevalle drie groeiringe (waarskynlik jaarringe), terwyl in ander gevalle minder duidelike of glad geen groeiringe te sien is nie. Die groeiringe is nie duidelik afgebaken nie en is in 'n stingel nie oral ewe duidelik waarneembaar nie. Takke aan al die kante van 'n struik, se groeiringe is ewe onduidelik sigbaar.

Waar groeiringe waarneembaar is, kan lente- en somerhout onderskei word op grond van die aantal vate en die selwanddikte van die vesels. In die lentehout kom heelwat vate en baie parenchiem voor, ingebed in 'n grondmassa van veseltracheïede (fig. 7). Hier is die radiale rangskikking van die xileemelemente versteur deur die groot aantal wye vate. Somerhout (laat hout) besit minder en effens smaller vate wat verder uitmekaar en dikwels enkeld geleë is, minder parenchiem, en 'n grondmassa van egte (libriforme) vesels (fig. 8). By *L. adscendens* kom soms 'n strokie vesels (ongeveer vier tot ses sellae breed) sonder enige vate voor op die grens tussen twee groeiringe.

Die xileemvate toon 'n diffuse verspreiding, hoewel hulle 'n weinig meer talryk in lente- as in somerhout is. In 'n dwarssnee is die vate apart of in klein groepies langs mekaar gerangskik sodat onvolledige tangensiale bande of stroke gevorm word. Dit lyk of die vate en xileemparenchiem ingebed is in 'n veselmassa.

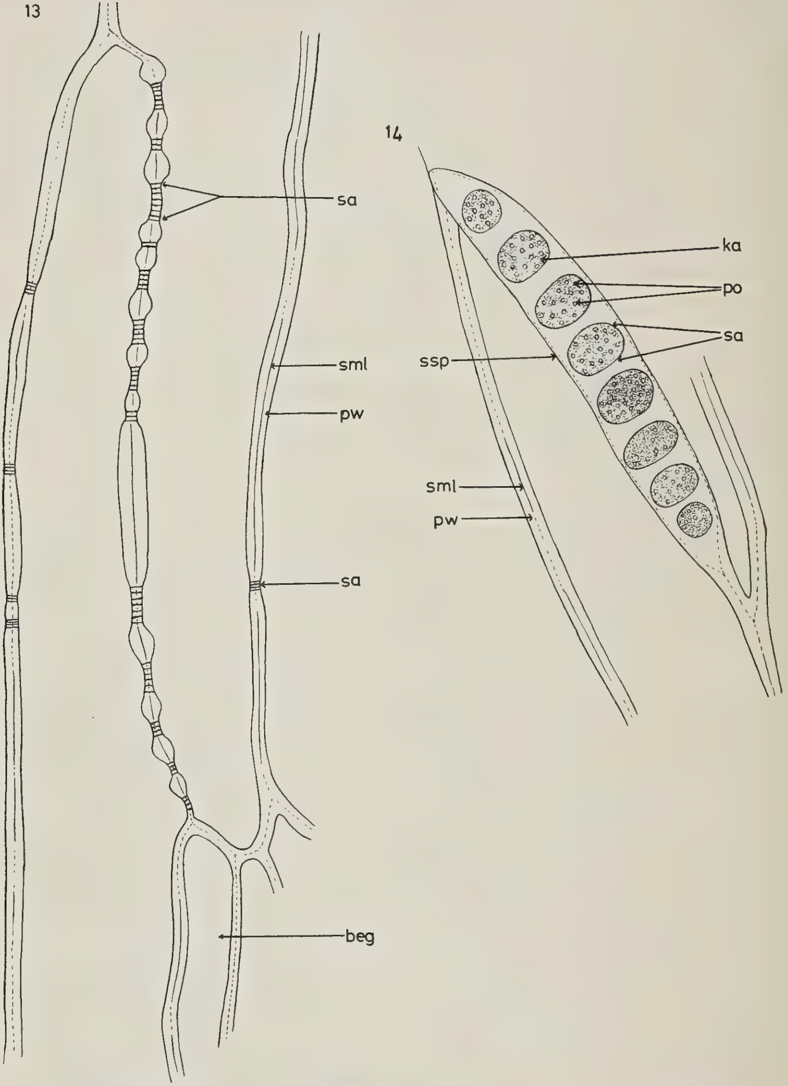
Die deursnee van die vate is 52—58μ vir *P. repens* en 22—33μ vir *L. adscendens*. Die lengte van die vaatsegmente wissel van 340—490μ by *P. repens* en 240—340μ by *L. adscendens*. Ongeveer 210—310 vate per vk mm kom voor by beide soorte. Slegs stippelvate met alternerende skuinsgeplaasde spleet- en kruisspleethofstippels kom voor. Die vaatsegmente het skuinsgeplaasde eenvoudige perforasieplate met lang stertjies (fig. 16).

Die xileemparenchiem is paratracheaal en in stroke of groepies van een tot twee selle wyd, buite die groepe vate aanwesig. Die selle is smal en verleng, met dwarsgeplaasde eindwande. Hulle is 185—265μ lank en 20—25μ breed by *P. repens*, en 120—290μ lank by *L. adscendens*. Hul wande is verdik, effens verhout en besit eenvoudige stippels.

Vesels is talryk in die xileem en besit dik verhoute wande. Hul het ongeveer dieselfde deursnee as die parenchiemselle maar het kleiner lumens as gevolg van die dikker wande. Hul is ongeveer 780—980μ lank by *P. repens* en 480—680μ by *L. adscendens*. Hulle vorm die grondmassa waarin die vate en xileemparenchiem ingebed is. Sommige vesels, veral in die somerhout, het eenvoudige of geen stippels nie en is dus egte (libriforme) vesels. In die lentehout het hulle swak ontwikkelde hofstippels en is dus eerder veseltracheïede. Daar is waarskynlik geen egte tracheïede aanwesig nie, maar wel oorgangsvorme tussen laasgenoemde en veseltracheïede, asook tussen egte vesels en veseltracheïede.

Binnekant die sekondêre xileem word die primêre xileembundels en groepies xilêre vesels nog soos voorheen aangetref. Die selwande van laasgenoemde is sterker verhout. Die vate van die primêre xileem is effens nouer as die in die sekondêre xileem en die elemente toon min radiale rangskikking.

(d) *Vaatstrale*. Daar kom twee tipes vaatstrale voor in die sekondêre vaatweefsel (fig. 4): twee tot 'n paar selle breed (multiseriaal) en slegs een sel breed (uniseriaal). Multiseriale strale ontstaan uit straalinisiales



FIGE. 13, 14.

Details van sifbuise van *Protea repens*, × 600: fig. 13, sifplaat in lengtesnee; fig 14, sifplaat in vooraansig; beg, begeleidende sel, ka, kallose; po, porie; pw, primêre wand; sa, sifareas; sml, saamgestelde middellamella; ssp, saamgestelde sifplaat.

wat in die murgstrale, en dus interfassikulêr, gevorm word wanneer sekondêre groei begin. Dit lyk dus asof die murgstrale geleidelik oorgaan in multiseriale strale. Die uniseriale strale ontstaan uit straalinisiales in die intrafassikulêre kambium. Die beginpunte van die langste uniseriale strale toon waar sekondêre vaatweefsel begin. Die strale is in tangensiale lengtesnee een tot baie selle hoog.

Die vaatstrale is homogeen en bestaan uit neerliggende straalparenchiemselle, wat smal is en effens radiaal verleng, met meesal tannienagtige inhoude (gestippeld in fig. 4). By *L. adscendens* kom ook setmeelkorrels in die straalselle voor. Die selwande is dun en onverhout in die sekondêre floëem, en verhout in die sekondêre xileem. In die floëem verdik en verhout die wande van sommige selle van die multiseriale strale, om groepies steenselle (sklereïede) in die middel van die floëemstraal te vorm, met gewone straalparenchiem aan die rande.

Beide uni- en multiseriale vaatstrale, maar veral laasgenoemde, toon dilatasie. Dit geskied veral deur selvergroting en baie min deur seldeling. Die strale word wyer na buite deur selstrekking in tangensiale rigting. Dilatasie is veral waarneembaar in die multiseriale strale van die floëem en jonger xileem, in die straalparenchiemselle weerskante van die steenselle.

Die multiseriale strale van *P. repens* is ongeveer 30—120μ (twee tot ses selle) breed en 0·5—2·5 mm en selfs tot 4 mm hoog, in die jongste sekondêre xileem gemeet. Die uniseriale strale is 13μ breed en 0·8—1·8 mm hoog. By *L. adscendens* wissel die vaatstrale van 1·0—3·9 mm hoog en van 10—95μ wyd.

4. Bou van die veel ouer stam

Twee stamme van *P. repens* en een van *L. adscendens* is ondersoek. Die ouderdomme is bepaal op grond van die simpodiale stingelvertakkings. Die stam van *L. adscendens* is 3·5—3·8 cm in deursnee en 12 jaar oud. Die 16 jaar oue stam van *P. repens* is 12—12·5 cm en die 12 jaar oue stam 5·3—5·7 cm in deursnee.

Periderm. Geen rhytidoma kom voor nie, want die oorspronklike fellogeen is nog steeds (en bly miskien lewenslank) aktief. Dis opvallend dat slegs 'n baie dun kurklagie aanwesig is in verhouding tot die dikte van die stam. By *P. repens* wissel die breedte daarvan van 120—300μ terwyl by *L. adscendens* 'n heelwat breër kurklaag aangetref word, nl. 290—780μ breed. Die ouer kurklae skilfer af en daarom is die epidermis ook verlore.

Die grootste, buitenste deel van die kurklaag bestaan uit radiaal afgeplatte,

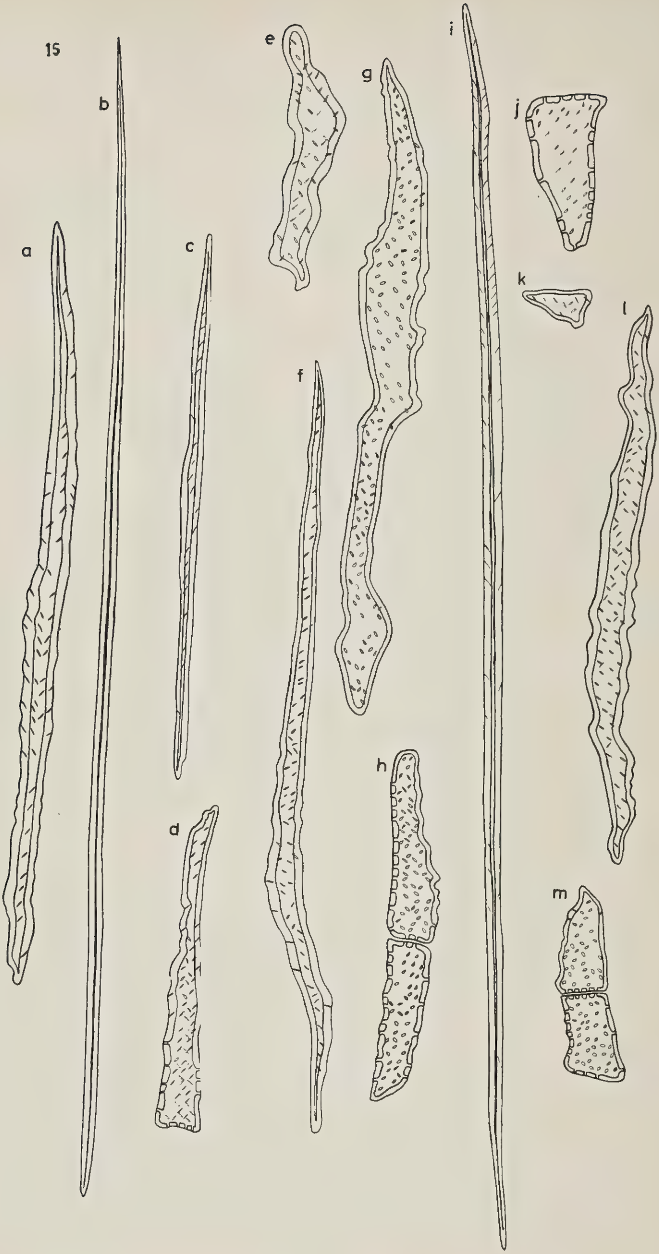


FIG. 15.
Verhoute elemente uit die gemaseerde sekondêre floëem van *Protea repens*, × 125; b, c, i, egte vesels; a, d-h, j-m, steenselle.

donkerbruin, tannienbevattende, dooie selle. Die binneste paar kurksellae toon die tipiese bou soos by die jonger stingels. Daaronder is die fellogeen te onderskei. Geen felloderm kom voor nie, behalwe vir twee tot vier lagies onder die lentiselle.

Dilatasie by die kurk geskied deur tangensiale selstrekking en hier en daar radiale lengtedelings in die fellogeen. By *P. repens* is die nuwe kurkselle nou 55—66μ breed in tangensiale rigting in teenstelling met 22—40μ by jonger stingels.

Lentiselle van verskillende groottes is redelik volop in die ou *P. repens*-stamme. Die bou daarvan stem ooreen met die van die jonger stingels. Die bou van lentiselle by die ou *L. adscendens*-stam kon nie met sekerheid nagegaan word nie.

Skors. Aangesien die oorspronklike fellogeen aktief bly, is die skors nog aanwesig. Dit is heelwat breër as by driejarige stingels: by *P. repens* 1·0—1·1 mm en by *L. adscendens* 780—980μ breed. Die skors is deur tangensiale seldelings verbreed tot 26 sellae in teenstelling met die 10—15 sellae by driejarige *P. repens*-stingels, en tot 15 lae in teenstelling met agt by *L. adscendens.*

Dilatasie van die skors geskied deur radiale seldelings en deur 'n geweldige selstrekking in tangensiale rigting. Die skors is nou baie ryker aan tannien, steenselle en setmeel (lg. by *L. adscendens*) as by driejarige stingels.

Floëem. In plaas van die aaneenlopende sklerenchiemlaag, word die vesels en steenselle op die grens tussen die skors en sekondêre floëem aangetref in 'n onreëlmatige, onderbroke laag. Hierdie toestand is te wyte daaraan dat die sklerenchiemlaag nie dilateer nie en onreëlmatig verskeur het.

Die sekondêre floëem is taamlik breed in vergelyking met die smal kurklaag en skors, maar is baie smaller as die sekondêre xileem. By die 16 jaar oue *P. repens*-stam is 2—2·3 mm breë sekondêre floëem aanwesig en 5·1—5·8 cm breë sekondêre xileem. Die buitenste deel van die floëem funksioneer nie meer nie en slegs die binneste ongeveer 250μ breë strokie by *P. repens*, en 290—340μ by *L. adscendens*, is funksionerend.

In die nie-funksionele deel van die floëem is vesels aanwesig. By *P. repens* vorm die vesels lagies van ongeveer 146—176μ breed, afwisselend met die deels geoblitereerde dunwandige floëemelemente. Die vesels dui nie groeiringe in die floëem aan nie. Na buite is die dunwandige floëemelemente geleidelik al meer geoblitereer, sodat die elemente daar nie meer te onderskei is nie. By *L. adscendens* vorm die vesels nie lagies nie, maar kom versprei deur die nie-funksionerende floëem voor, enkeld of in groepies.

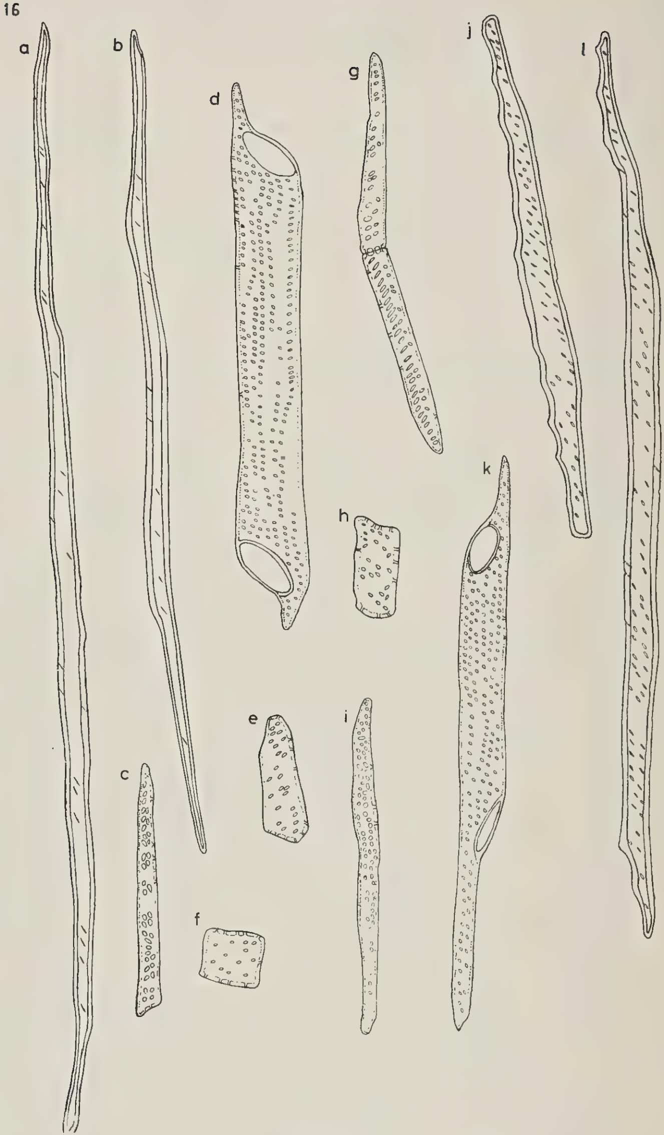


Fig. 16.
Verhoute elemente uit die gemaseerde sekondêre xileem van *Protea repens*, × 125; a-b, egte vesels; d, k, stippelvaatsegmente; e, f, h, vaatstraalparenchiemselle; c, g, i, xileemparenchiem; j, l, veseltracheïede.

Kambium. Dit bestaan uit 'n baie smal gordel meristematiese selle tussen die sekondêre xileem en floëem.

Xileem. By *P. repens* bestaan die grootste binneste donkerbruin deel van die sekondêre xileem uit kernhout. Die spinthout daaróm is ligbruin met 'n pienkerige skynsel. Die grens tussen kernhout en spinthout is nie skerp nie en nie oral ewe duidelik nie. Die kernhout is geïmpregneer met 'n donkerrooi stof wat tannienagtig van aard is. Al die xileemparenchiemselle is hier dood en gevul met tannien. Baie vate is ook gevul met tannien. Geen thylle kom voor nie. Die hout van *L. adscendens* is ligbruin van kleur met 'n pienk tint, en geen kernhout is te onderskei nie.

Groeiringe is nie baie duidelik nie, maar is tog waarneembaar, veral in die kernhout. By die 16 jaar oue *P. repens*-stam is 16 groeiringe, wat dus jaarringe voorstel, te onderskei. Waar groeiringe redelik opvallend is, sal die ouderdom van plante daarvolgens bepaal kan word, hoewel die tel van simpodiale stingelvertakkings miskien 'n meer betroubare kriterium is. Hoewel groeiringe soms by *L. adscendens* te onderskei is, is hul nie duidelik afgebaken nie, en dit lyk nie moontlik om die ouderdom hier te bepaal deur die groeiringe te tel nie.

Dieselfde elemente word in die sekondêre xileem aangetref as voorheen. By die ouer stam is 'n sterker neiging tot tangensiale rangskikking van vate as by jonger stingels, en hier word selfs tangensiale bande van vate aangetref wat van een straal tot die volgende strek. Die vate het 'n groter deursnee as by die jonger stingels, nl. 50—75μ by *P. repens* en 40—46μ by *L. adscendens*, maar die vaatsegmente is korter as by jonger stingels, nl. 200—370μ by *P. repens* en 200—310μ by *L. adscendens*. Daar is minder vate per vk mm aanwesig as by jonger stingels, nl. 80—130 by *P. repens* en 210—260 by *L. adscendens*. Bou van die vate is dieselfde as voorheen beskryf.

Die xileemparenchiem toon dieselfde rangskikking en bou as voorheen.

Die grondmassa van die xileem bestaan uit alle moontlike oorgangsvorms tussen vesels en tracheïede en tussen vesels en steenselle, asook uit egte vesels. Die vesels is 0·6—1·1 mm lank by *P. repens* en 340—680μ by *L. adscendens* wat nie veel verskil van dié by jonger stingels nie.

Die aparte primêre xileembundels en groepies vesels is nog sigbaar en vorm deel van die kernhout. Die parenchiemselle hier is dood, die selwande gekartel en die selle ryk aan tannien.

Vaatstrale. Soos voorheen kom multi- en uniseriale vaatstrale voor. Die aantal uniseriale strale vermeerder steeds na buite, waarskynlik deurdat spilvormige kambiuminisiales verander tot straalinisiales deur seldeling.

Die selle van beide tipes strale vergroot geleidelik na buite in tangensiale en radiale rigtings. Dilatasie geskied nog deur veral selvergroting maar ook deur seldelings, waardeur sommige uniseriale strale tot multiseriale strale verander. By *L. adscendens* geskied dilatasie veral in die multiseriale strale. As gevolg van die geweldige dilatasie is die multiseriale strale by hierdie soort naby mekaar geleë in die floëem en die jongste xileem, en ongeveer net so breed as die sektors van vaatweefsel daartussen. Steenselle word in die middel van multiseriale strale by beide spesies aangetref. Geen verdeling van multiseriale strale tot smaller strale is gevind nie.

In 'n tangensiale lengtesnee is die vaatstrale van *P. repens* drie tot vier mm hoog en tot 0·5 mm breed in die jongste sekondêre xileem gemeet, en dié van *L. adscendens* tot 4 mm hoog en tot 0·4 mm breed.

Murg. Die murg is nog aanwesig en het ongeveer dieselfde breedte as in driejarige stingels. Die verhoute selwande is dikker as voorheen, en die selle dood en baie ryk aan tannien.

5. Bou van die Knope

By die jong stingel (figure 17—20). In die knope kan die vaatweefsel in drie dele ingedeel word: vaatweefsel van die as, vaatbundels na die blaar (blaarspore) en vaatbundels na die okselknop (okselknopspore).

Na elke blaar loop 'n groot mediane en twee kleiner laterale blaarspore. Hulle toon dieselfde bou as die primêre stingelvaatbundels en besit vereers slegs primêre, maar later ook sekondêre vaatweefsel.

By *P. repens* verlaat een laterale blaarspoor die stingelvaatweefsel eerste. ongeveer twee tot drie litte onder die blaarbasis. Dit loop geleidelik skuins deur die skors na die blaarbasis. Die tweede laterale spoor verlaat die kring vaatbundels in ongeveer die tweede lit onder die blaarbasis. Die mediane spoor verlaat die kring in die lit direk onder die blaarbasis. By *L. adscendens* verlaat die mediane bundel die stele eerste, ongeveer twee litte onder die blaarbasis (fig. 18a), en die twee laterale bundels ongeveer gelyktydig in die lit direk onder die blaarbasis (fig. 18b).

Lengtesneë toon dat die hoeke waarmee die drie blaarspore na die blaarsteel buig, verskil. By *P. repens* loop die twee laterale spore geleidelik skuins na die blaarsteel en vorm 'n klein hoek met die as (fig. 19). Die mediane bundel buig vinniger uit en vorm 'n groter hoek (fig. 20).

By *P. repens* dring die laterale blaarspore eerste die blaarsteel binne, gevolg deur die mediane spoor. Die omgekeerde geld vir *L. adscendens*. By *P. repens* vertak eerste die laterale bundels en dan die mediane bundel, elk in ongeveer drie takke, wat in die blaarsteel tot 'n wisselende mate vertak en weer verenig (fig. 17c–d). By *L. adscendens* vertak die bundels eers hoër op in die blaarsteel sodat in die blaarbasis slegs drie bundels aangetref word.

Bokant die plek waar 'n blaarspoor die stele verlaat, word 'n blaarvenster

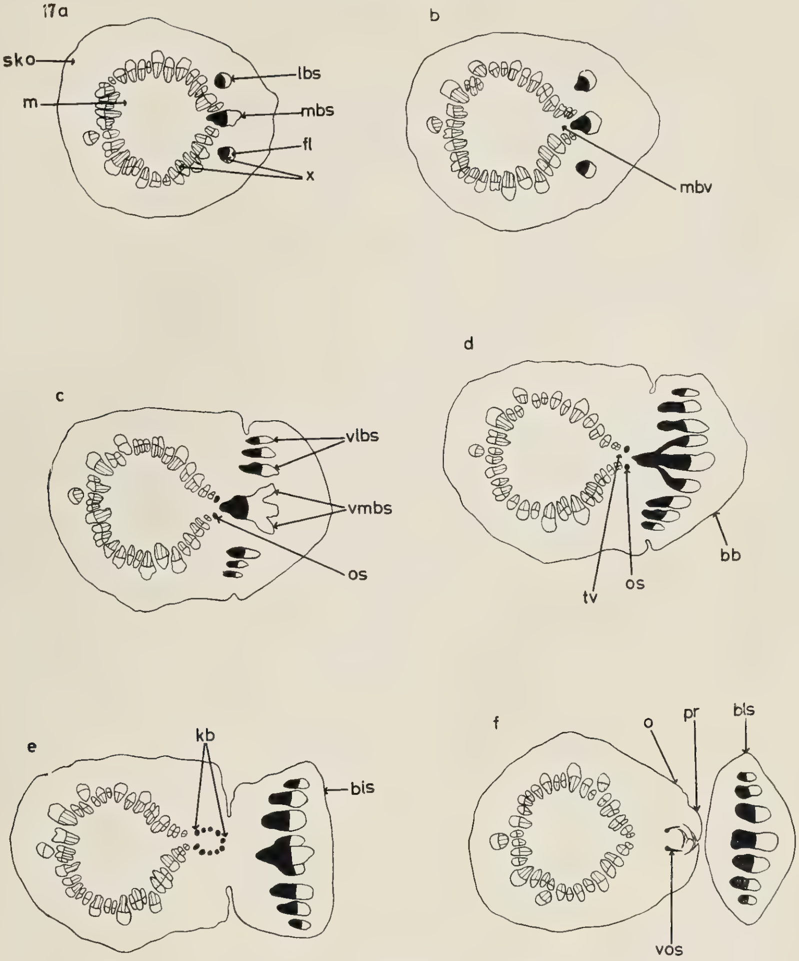


FIG. 17.

Diagramme van 'n reeks dwarssneë om die verloop van blaarspore en okselknopspore by *Protea repens* te illustreer, van a, laag, tot f, hoog, × 8; bb, blaarbasis; bls, blaarsteel; fl, floëem; kb, kring van okselknopbundels; lbs, laterale blaarspoor; m, murg; mbs, mediane blaarspoor; mbv, mediane blaarvenster; o, okselknop; os, okselknopspoor; pr, profil; sko, skors; tv, gesamentlike tak- en blaarvenster; vlbs, vertakte laterale blaarspoor; vmbs, vertakte mediane blaarspoor; vos, vertakte okselknopspoor; x, xileem.

van parenchiem aangetref. Aangesien daar drie blaarvensters i.v.m. elke blaar staan, is die knope by beide soorte trilakunêr. Die laterale vensters is klein, maar die mediane venster is groter en is aaneenlopend met die okselknopvenster (takvenster) net bokant die okselknopspore.

Die okselknoppe kom een tot twee mm bokant die oksels van die blare, teen die stingel, voor. Hulle word voorsien deur twee takspore (hier okselknopspore genoem omdat die takke nog in die okselknopstadium is). Die okselknopspore is heelwat kleiner as die blaarspore, maar het dieselfde bou as laasgenoemde.

Die twee klein okselknopspore verlaat die stele ná die mediane blaarspoor (by *P. repens*) of na die twee laterale spore (by *L. adscendens*) (figure 17c, d, 18b). Hierdie okselknopspore spruit uit die vaatweefsel teen die rande van die mediane blaarvenster, lê eers as halfmaanvormige boë in die skors (fig. 18d), loop dan skuins na bo na die okselknop en vertak terselfdertyd in 'n hele aantal klein vaatbundels (fig. 17e). Laasgenoemde lê in 'n volledige silinder onder die okselknop vanwaar die bundeltjies na die verskillende skubblare van die okselknop gaan (fig. 17e, f). Die eerste twee bundeltjies gaan na die eerste twee skubblare (profille). Die okselknopspore bestaan dus in werklikheid uit aggregasies van spore na die verskillende vroeë blare (skubblare) van die okselknop.

Gedurende sekondêre groei by ouer stingels (fig. 21). Wanneer sekondêre groei in die stingel begin, word kambium in die parenchiem van die blaarvenster gevorm. Hierdie kambium vorm dan sekondêre vaatweefsel oor die blaarvenster, sodat laasgenoemde geleidelik gesluit word. In die driejarige stingel besit elke blaarvenster sekondêre vaatweefsel teen sy rande, met 'n breë multiseriale vaatstraal teenoor die blaarspoor. Die kleiner laterale vensters word gouer gesluit as die mediane venster. In 'n mediane lengtesnee deur die blaarsteel en stingel is 'n klein gedeelte van die blaarvenster aan die buitekant van die kambium te sien, bestaande uit dunwandige parenchiem met groepe steenselle daarin, en 'n stukkie blaarvenster teen die murg, bestaande uit verhoute parenchiemselle.

By vierjarige *P. repens*-stingels is die blare nog nie afgewerp nie en die blaarspore nog nie afgebreek deur die sekondêre vaatweefsel wat in die blaarvenster gevorm is nie. Die blare van *P. repens* word afgewerp eers waar die stingels 10—12 jaar oud is. Hoewel al die blare van *L. adscendens* reeds in die tweede jaar afgewerp word, word die blaarspore nie deur die sekondêre vaatweefsel afgebreek nie, selfs in stingels van ses jaar oud.

BESPREKING

Van die Suid-Afrikaanse Proteaceae is die houtanatomie van *Protea elliottii*, *P. grandiflora*, *P. lepidocarpon* en *Leucadendron argenteum* deur Chattaway

(1948a) ondersoek. Metcalfe en Chalk (1950) gee tekeninge van die stingel- en houtanatomie van *Protea cynaroides*, *P. pulchella* en *Leucadendron argenteum* aan.

Die gegewens oor die algemene stingelanatomie en histologie van *Protea repens* en *Leucadendron adscendens* sal nou kortliks vergelyk word met die resultate van die vorige navorsers by ander lede van die Proteaceae.

Die bou van die periderm van die huidig ondersoekte spesies stem ooreen met dié van die vorige ondersoekte spesies (Engler, 1893; Metcalfe en Chalk). Solereder (1899) asook Metcalfe en Chalk meld dat die kurk in die subepidermis ontstaan by spesies van *Banksia*, *Dryandra*, *Grevillea*, *Hakea*, *Persoonia*, *Stenocarpus*, ens. Nou is getoon dat die fellogeen beide in die buitenste skorslaag asook in die epidermis ontstaan, selfs by een en dieselfde stingel.

Die bou van die lentiselle is nou waarskynlik vir die eerstemaal by die Proteaceae beskryf, asook die feit dat die oorspronklike fellogeen vir minstens 16 jaar aktief bly, en dat daar dus geen rhytidoma is nie en die skors vir minstens die 16 jaar blywend is. Dit verskil van *Dryandra* waar dieperliggende sekondêre fellogene soms voorkom (Metcalfe en Chalk).

In die huidige ondersoek is Metcalfe en Chalk se vermelding dat tannien voorkom in die skors, murg, murgstrale en floëem van die Proteaceae, bevestig. By *P. repens* is kalsiumsalaatkristalle gevind. Sulke kristalle is volgens Metcalfe en Chalk skaars by die Proteaceae, hoewel aanwesig by o.a. *Banksia*, *Dryandra*, *Grevillea*, *Hakea*, e.a. By beide huidig ondersoekte soorte kom groepe steenselle in die skors en murg voor. Engler, Solereder en Metcalfe en Chalk noem ook die teenwoordigheid van steenselle by die familie, o.a. by *Leucadendron argenteum*, *Leucospermum conocarpum*, *Banksia*, *Dryandra*, *Grevillea* en *Hakea*.

Behalwe vir die blaarspore is geen skorsbundels by die huidig ondersoekte soorte gevind nie, hoewel Metcalfe en Chalk dit noem vir soorte van *Protea*, *Banksia* en *Dryandra*. Dis moontlik dat hulle die blaarspore, sommige waarvan, soos nou aangetoon, deur verskeie litte loop voor hulle na die blare divergeer, met ware skorsbundels verwar het.

By die huidig ondersoekte soorte word groepe ekstraxilêre vesels by jong stingels buite die vaatbundels aangetref, en by effens ouer stingels is 'n breër, aaneenlopende sklerenchiemlaag van vesels en steenselle binne die ekstraxilêre vesels aanwesig. Solereder en Metcalfe en Chalk noem ook die teenwoordigheid van 'n sklerenchiemlaag in die perisikel by die familie, bv. by spesies van *Banksia*, *Grevillea*, *Hakea*, *Knightia* ens. Die sklerenchiem skyn dus 'n wydverspreide familiekenmerk te wees.

In die floëem besit die sifbuise saamgestelde sifplate op die skuins eindwande en sifareas op die lengtewande. Dit stem ooreen met Engler en Solereder se beskrywings. In die ou stam word tangensiale strokies (*P. repens*) of verspreide groepies (*L. adscendens*) vesels in die ou, nie-funksionerende floëem aangetref, maar hulle dui geen groeiringe aan nie. Metcalfe en Chalk noem ook die voorkoms van vesels in die floëem by spesies van *Banksia*, *Dryandra*, *Grevillea*, *Hakea* ens., maar volgens hulle ontbreek dit by *Protea*.

Wanneer sommige van die protoxileemvate hul funksie verloor, word hulle vernietig, terwyl die aangrensende parenchiemselle groepe xilêre vesels vorm. Solereder vermeld ook die teenwoordigheid van vesels aan die buiterand van die murg, teen die primêre xileem, by die Proteaceae.

Drie soorte xileemelemente word in die sekondêre xileem aangetref, soos ook deur Solereder, Metcalfe en Chalk en deur Chattaway (1948a) vir die familie beskryf: xileemvate, -parenchiem en -vesels.

By *P. repens* en *L. adscendens* toon die vate 'n diffuse verspreiding wat ooreenstem met die bevindings van Metcalfe en Chalk en van Chattaway. Die vate kom enkeld of in klein groepies voor en vorm kort tangensiale bande. *L. adscendens* toon 'n sterker neiging tot tangensiale rangskikking van vate as *P. repens*. Volgens Chattaway is die vate soms oorheersend enkeld (bv. *Faurea*), soms enkeld of in kort tangensiale of radiale groepe (bv. *Roupala*, *Protea*) en soms toon hulle 'n opvallende tangensiale rangskikking (bv. *Knightia*).

Eenvoudige perforasieplate kom by die huidig ondersoekte soorte voor. Dit is ook deur Engler, Solereder, Metcalfe en Chalk, en Chattaway genoem vir die soorte wat hulle ondersoek het.

Die deursnee van die vate is 52—58μ vir *P. repens* en 22—33μ vir *L. adscendens*. Volgens Metcalfe en Chalk is die vate 50—200μ in deursnee en soms groter. In die huidige ondersoek is 210—310 vate per vk mm by die jong stingels van beide soorte aangetref. Volgens Metcalfe en Chalk is daar 5—15 vate per vk mm by die Proteaceae en soms selfs minder (bv. sekere spesies van *Protea*, *Embothrium*, *Stenocarpus*). Hierdie gegewens stem dus glad nie ooreen met dié wat in die huidige ondersoek verkry is nie. Die lengte van die vaatsegmente is 340—490μ by *P. repens* en 240—340μ by *L. adscendens* by jong stingels, en korter by ouer stingels. Dit stem naastenby ooreen met Metcalfe en Chalk se opgawe dat die segmente meestal 0·3—0·5 mm lank is (maar soms tot 0·9 mm lank).

By die huidig ondersoekte soorte word paratracheale xileemparenchiem aangetref, as enkele selle of in kort, tangensiale bande net buite die vate. Volgens Chattaway kan xileemparenchiem para- of apotracheaal wees by die Proteaceae, terwyl die rangskikking daarvan netvormig (bv. *Helicia*), vlerkvormig tot saamvloeiend (bv. *Stenocarpus*), of in tangensiale bande (kenmerkend vir die familie) kan wees.

By die huidig ondersoekte soorte is die xileemvate en -parenchiem ingebed in ’n „grondmassa” van vesels. Laasgenoemde elemente besit eenvoudige stippels tot swak ontwikkelde hofstippels en varieer dus van egte vesels tot veseltracheïede. Volgens Metcalfe en Chalk kom vesels met dik wande en hofstippels met duidelike krae voor by sommige *Faurea-*, *Protea-* en *Persoonia* soorte, terwyl die vesels sonder stippels of met onduidelike stippels is by o.a. *Grevillea* en *Leucadendron*. Volgens Chattaway is die selwande van vesels redelik dun en onduidelike hofstippels kom voor by *Leucadendron argenteum*, terwyl die vesels van die drie *Protea*-spesies wat sy ondersoek het, dun selwande en talryke hofstippels besit.

In die huidige ondersoek is geen regte tracheïede in die hout gevind nie, maar wel oorgangsvorms tussen vesels en tracheïede en tussen vate en tracheïede. Volgens Chattaway kom egte tracheïede selde voor, maar is oorgangsvorms volop.

Die hout van beide soorte wat nou ondersoek is, is ligbruin van kleur met ’n pienk tint. Pienk en rooi getinte hout is, volgens Chattaway, algemeen by die familie.

Groeiringe is onduidelik afgebaken by die huidig ondersoekte soorte. Chattaway het dieselfde gevind by die drie *Protea*-spesies wat sy ondersoek het, asook by *Leucadendron argenteum*.

Uni- en multiseriale vaatstrale kom voor by *P. repens* en *L. adscendens*. Chattaway vind ook die twee soorte strale by drie *Protea*-spesies, en volgens haar is groot strale opvallend by die Proteaceae. Die multiseriale strale van *P. repens* is 0·5—4 mm hoog en 0·1—0·5 mm breed, en dié van *L. adscendens* is 1—4 mm hoog en 0·1—0·4 mm breed. Die hoogste strale is hoër as wat Chattaway by *Leucadendron argenteum* vind (selde meer as 1·5 mm), en die breedste strale is breër as wat Metcalfe en Chalk as tipies vir die strale van die Proteaceae beskou (0·2—0·3 mm), hoewel hulle meld dat ook wyer strale mag voorkom. Net soos by die huidig ondersoekte soorte, is steenselle in die multiseriale vaatstrale aangetref by lede van verskeie genera (Chattaway). Die strale van die soorte wat nou ondersoek is, is homogeen, behalwe vir die aanwesigheid van die gemelde groepe steenselle in die middelstrook van ouer multiseriale floëemstrale. Volgens Chattaway (1948b) en Rao (1957) kom vaatweefsel voor in die strale van *Banksia* en *Dryandra*. So iets is nie by die huidig ondersoekte soorte aangetref nie.

Die bou van die knope en die verloop van die blaarspore en okselknopspore is nou waarskynlik vir die eerstemaal ondersoek by lede van die Proteaceae. By *P. repens* en *L. adscendens* kom trilakunêre knope voor. Elke blaar word deur drie blaarspore en elke okselknop deur twee okselknopspore voorsien. Die

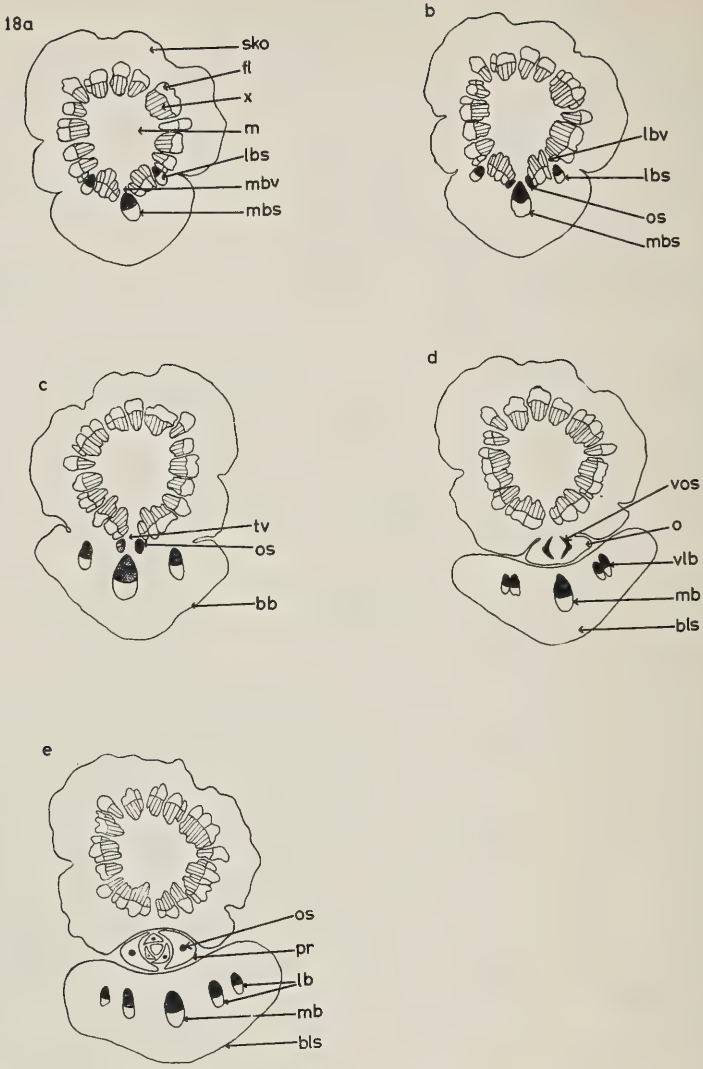


FIG. 18.
Diagramme van 'n reeks dwarssnëe om die verloop van blaarspore en takspore by *Leucadendron adscendens* te illustreer, van a, laag, tot e, hoog, × 13; bb, blaarbasis; bls, blaarsteel; fl, floëem; lb, laterale bundel; lbs, laterale blaarspoor; lbv, laterale blaarvenster; m, murg,, mb, mediane bundel; mbs, mediane blaarspoor; mbv, mediane blaarvenster; o, okselknop; os, okselknopspoor; pr, profil; sko, skors; tv, blaar- en takvenster; vlb, vertakte laterale bundel; vlbs, vertakte laterale blaarspoor; vos, okselknopspoor; x, xileem.

okselknopvenster en mediane blaarvenster is aaneenlopend. Omdat in die literatuur geen gegewens gevind kon word oor knoopbou by die Proteaceae nie, is dit op hierdie tydstip onmoontlik om te sê in hoeverre die trilakunêre knoop en drie blaarspore tipies is vir die familie.

OPSOMMING

Die anatomie en histologie van die stingels van *Protea repens* (L.) L. non Thunb. en *Leucadendron adscendens* R. Br. is nagegaan en vergelyk. Die stingelbou by die twee soorte stem in groot mate ooreen.

1. In die jong stingels lê die primêre vaatbundels dig teenmekaar in 'n onreëlmatige kring, met smal murgstrale tussen hulle. Wanneer die sekondêre groei begin, word 'n aaneenlopende silinder van sekondêre vaatweefsel gevorm. Uni- en multiseriale vaatstrale kom voor, laasgenoemde regoor die murgstrale. Kurkvorming begin gedurende die eerste (*P. repens*) of tweede (*L. adscendens*) groeiseisoen.

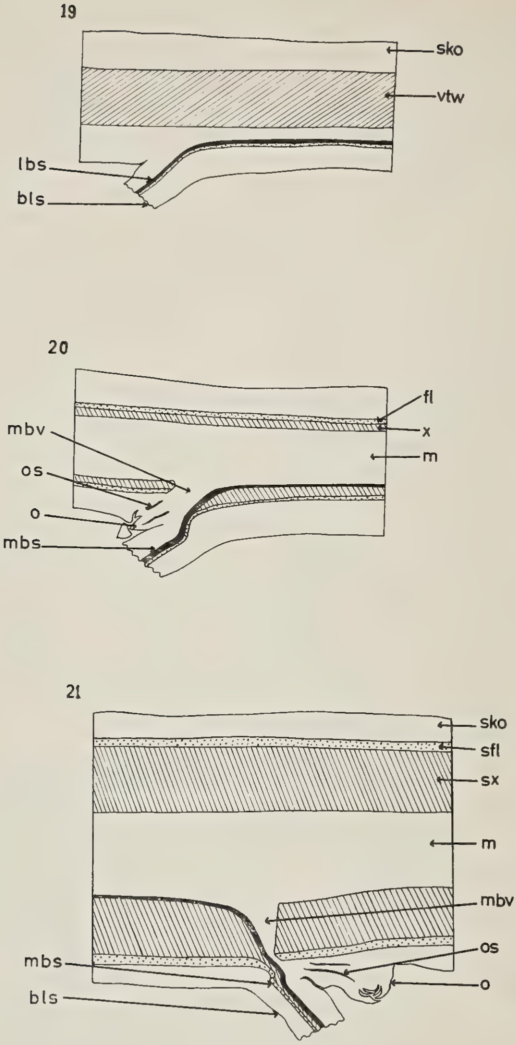
2. Ou stamme, 12 en 16 jaar oud, toon geen rhytidoma nie, maar 'n enkele baie dun kurklaag en fellogeen sonder sekondêre skors. Die primêre skors bly behoue en toon dilatasie. Min sekondêre floëem is aanwesig in vergelyking met die breë strook sekondêre xileem. Die hout is diffuusporeus, en bestaan grotendeels uit kernhout by *P. repens*. Groeiringe is waarneembaar, hoewel onduidelik afgebaken. Dilatasie van die vaatstrale geskied hoofsaaklik deur selvergroting maar ook deur radiale seldelings, waardeur uniseriale strale tot multiseriale strale verander, en multiseriale strale meer selrye kry.

3. Trilakunêre knope kom voor. Na elke blaar loop 'n mediane en twee laterale blaarspore, terwyl elke okselknop deur twee okselknopspore voorsien word. Die okselknopvenster is aaneenlopend met die mediane blaarvenster.

4. Spesiale aandag is gegee aan die histologie van die kurk, floëem en xileem. Die fellogeen ontstaan in die epidermis of in die buitenste sellaag van die skors en bly jare lank aktief. 'n Betreklik dun kurklagie van dunwandige kurk kom voor. Die vulselle van die lentiselle het verkurkte selwande.

5. In die floëem kom sifbuise, begeleidende selle en floëemparenchiem voor. Die sifbuise het saamgestelde sifplate op die skuins eindwande en sifareas op die lengtewande, op beide waarvan kallose voorkom. Ouer floëemweefsel word gedeeltelik geoblitereer en gedeeltelik verander tot lagies of groepies floëemvesels.

6. In die xileem kom xileemvate, xileemparenchiem, egte vesels en veseltracheïede voor. Die vate het eenvoudige perforasieplate. Die vesels en vesel-



Fige. 19—21.
Diagramme van sneë deur *Protea repens*-stingels om die knoopbou te illustreer: fig. 19, tangensiale lengtesneë deur die laterale blaarspoor van 'n jong stingel, × 6; fig. 20, radiale lengtesnee deur die mediane blaarspoor, × 6; fig. 21, radiale lengtesnee deur die mediane blaarspoor van 'n drie jaar oue stingel, × 4; bls, blaarsteel; fl, floëem; lbs, laterale blaarspoor; lbv, laterale blaarvenster; m, murg; mbs, mediane blaarspoor; mbv, mediane blaarvenster; o, okselknop; os, okselknopspoor; prx, primêre xileem; sfl, sekondêre floëem; sko, skors; sx, sekondêre xileem; vtw, vaatweefsel; x, xileem.

tracheïede vorm 'n „grondmassa" waarin die vate en xileemparenchiem ingebed is.

DANKBETUIGING

Dank is verskuldig aan dr. Miriam P. de Vos onder wie se leiding hierdie werk gedoen is, vir haar hulp, raad en waardevolle kritiek; aan die ander dosente van die Botaniedepartement vir hul raad en belangstelling; en aan mev. M. Vogts vir die verskaffing van 'n dik stam van *Protea repens*.

LITERATUURVERWYSINGS

CHATTAWAY, M. M. 1948(*a*). Wood anatomy of the Proteaceae. Austr. J. Sci. Res., B, **1** : 279—302.

CHATTAWAY, M. M. 1948(*b*). Note on vascular tissue in rays of *Banksia*. J. Counc. Sci. Industr. Res. Austr. **21** : 275—278. (vide C.V. Rao : 258).

ENGLER, A. 1893. Proteaceae. In A. Engler und K. Prantl, Die natürlichen Pflanzenfamilien, III, I : 119—122.

ESAU, K. 1943. Origin and development of primary vascular tissues in seed plants. Bot. Rev. **9** : 125—197.

ESAU, K. 1953. Plant Anatomy. London, John Wiley and Sons.

McLEAN, R. C. and Ivimey-Cook, W. R. 1941. Plant Science Formulae. London, MacMillan and Co.

METCALFE, C. R. and CHALK, L. 1950. Anatomy of the Dicotyledons, II. Oxford, Clarendon Press.

RAO, C. V. 1957. Cytotaxonomy of the Proteaceae. Proc. Linn. Soc. N.S.W. **82,** 384 : 258.

SASS, J. E. 1958. Botanical Microtechnique. Iowa, Iowa State College Press.

SOLEREDER, H. 1899. Systematic Anatomy of the Dicotyledons, **II.** Oxford, Clarendon Press.

STRASBURGER, E. and HILLHOUSE, W. 1900. Handbook of Practical Botany. London, Swan Sonnenschein and Co.

TASSI. 1898. Le Proteacee. Bull. del Lab. ed Orto bot. della Univ. di Siena 1898, pp. 67—134. (vide H. Solereder, 1899 : 1044).

VISSER, C. 1965. Anatomie van die stingels van *Protea repens* (L.)L. en *Leucadendron adscendens* R. Br. I. Bou en differensiasie van die groeipunte. J. S. Afr. Bot. **31** : 293—306.

WUTZ, A. 1955. Anatomische Untersuchungen über System und periodische Veränderungen der Lenticellen. Bot. Studien **4** : 43—71.

JOURNAL OF SOUTH AFRICAN BOTANY.

VOLUME 32 1966

INDEX OF PLANT NAMES

Note: New species etc. are printed in bold type. An asterisk indicates that the article is illustrated.

PAGE

Abildgaardia lanceolata Schumach 147
,, monostachya Vahl. . . 143
,, monostachya Vahl. Hassk. 147
,, tristachya Vahl. . . 147
Acacia karoo Hayne 67, 247, 249, 252
Acalypha peduncularis 5, 10, 21, 34
Agathosma peglerae. 6
Ajuga ophrydis 5
Alchemilla capensis 14
Alepidea ciliaris 10
Alloteropsis semialata . . 9, 14
Aloe mawii Christian 179
,, tenuior 254
Amaryllis revoluta 70
Amphibolia stayneri L.Bol. . . **126**
Amphithalea williamsonii 10, 11, 13
Anchusa capensis Thunb. 253, 255
Andropogon appendiculatus Nees. 255
Anemone caffra 5
Anisotoma mollis 5, 10
Anthospermum aethiopicum 2, 5–7, 10, 11, 20, 21, 29, 33, 37
Argyroderma litorale L.Bol. . . **229**
Argyrolobium stipulaceum . . 14
Aridaria barkerae L.Bol. **339**
,, beaufortensis L.Bol. . . **336**
,, klaverensis L.Bol. . . **336**
,, leipoldtii L.Bol. **337**
,, meyeri L.Bol. 339
,, nevillei L.Bol. **338**
,, paucandra L.Bol. forma 338
,, pillansii L.Bol. **337**
Aristea pusilla 9
,, spp. 14
Aristida congesta Roem. et Schult. 247
,, curvata (Nees) Trin. et Rupr. 247
,, galpini 9
,, junciformis ssp. galpinii Trin. et Rupr. 255
Asparagus asparagoides (L.) Wight 253
,, iocladus (sp. compact) . . 247

PAGE

Asparagus microraphis Kunth. . . 253
Aster filifolius Vent. 247
,, muricatus Less. . . 247, 255
Astridia alba L.Bol. **229**
,, citrina L.Bol. **230**
,, rubra (L.Bol.) L.Bol. var. alba L.Bol. 229
,, rubra (L.Bol.) L.Bol. var. citrina L.Bol. 230
,, vanbredai L.Bol. **127**
Athanasia punctata 9
Aulax cneorifolia Knight 78
,, pinifolia Berg. 78
Avena sativa 183

Berkheya buphthalmoides (DC.) Schltr. 255
,, carduoides . . 5, 9, 14
,, decurrens 4, 5, 9, 14
,, purpurea (DC.) Mast. . . 251
,, spp. 11, 31, 34
Berzlia intermedia 6
Blechnum australe L. 253
Bobartia burchellii 4, 5, 8, 9
,, indica 5, 9, 14
Brabeium stellatifolium Linn. 78, 84
Brachiaria serrata 9
Bromus leptocladus Nees. 250
Brunsvigia grandiflora 14
Bryum spp. 31
Buddleia salvifolia Lam. 252
Bulbine abyssinica A. Rich. . . 255
Bulbostylis sp. 9
Burchellia bubalina 14, 29

Caralluma piaranthoides Obermeyer 299
* ,, schweinfurthii Berger 299, 300, 302
Centella erianthe 10, 11, 14
Cephalophyllum pulchellum L.Bol. forma 336

PAGE

Chaetacanthus setiger (Pers.) Lindau 10, 14, 251
Cheilanthes multifida 253
,, spp. 255
Chironia melampyrifolia 5
,, spp. 10
Chrysocoma tenuifolia Berg. 247, 250
Clematis brachiata Thunb. 247, 253
Cliffortia paucistaminea H.Weim. 250,255
,, linearifolia 6, 10, 14, 15, 20, 21, 37
,, repens .. 2, 5, 6, 10, 14
*Clitocybe toxica E. L. Stephens **61**–64
,, olearia 61
Clutia alaternoides 10
,, heterophylla 2, 5, 6, 8, 10, 14, 21, 34
,, laxa Eckl. 255
,, pulchella L. .. 248, 252, 255
Conophytum altile N.E.Br. .. 206
,, ficiforme (Haw.) N.E. Br. 205–207
,, kennedyi L.Bol. .. **231**
,, komkansicum .. 336
,, lilianum Littlew. .. **235**
,, lithopoides L.Bol. .. 232
,, middlemostii L.Bol. **230**
,, odoratum (N.E.Br.) N.E.Br. 206
,, pallidum N.E.Br. .. 206
,, placitum (N.E.Br.) N.E.Br. 207
,, placitum (N.E.Br.) N.E.Br. var. pubescens Littlew. .. **207**
Crassula ericoides 14, 141
Crinum bulbispermum 68
,, capense 68
,, lineare L. 70
,, macowanii 68
,, macowanii ssp. confusum Verdoorn **67**, 68, 71
,, variabile (Jacq.) Herb. 68, 70, 71
Cussonia paniculata E. & Z. .. 248
Cymbopogon marginatus 9
,, plurinodes Stapf. ex Burtt Davy 247
,, proxilus (Stapf.) Phillips 250
Cyperus monostachyos Linn. .. 143
,, triflorus Linn. 147
Cyrtanthus contractus 2, 4, 5, 8, 36
,, o'brienii Bak. 255

Dactylis glomerata 183
Danthonia districha Nees. .. 250
,, macowanii Stapf. 250, 255

PAGE

Danthonia purpurea (Thunb.) Beauv. .. 250, 255
,, stricta (Nees.) Schrad 250
Delosperma abyssinicum 210
,, asperulum 210
,, ausense 210
,, clavipes Lavis **341**
,, cloeteae Lavis **343**
,, cooperi 210
,, crassum.. 210
,, deleenwiae Lavis .. **344**
,, echinatum 209
,, ficksburgense Lavis .. **342**
,, gramineum L.Bol. .. **203**
,, hallii 210
,, knox-daviesii Lavis .. **342**
,, klinghardtianum .. 210
,, kofleri Lavis **341**
,, longipes 209
,, lootsbergense Lavis .. **343**
,, mahonii 210
,, nakurense 210
,, oehleri 210
,, peersii Lavis **345**
,, pergamentaceum .. 210
,, steytlerae 210
,, suttoniae Lavis .. **344**
,, sp 251
,, truteri Lavis **343**
Diascia stachyoides Schltr. .. 253
Dierama pendulum 8
Digitaria smutsii Stent 183, 184, 187, 188
Diospyros whyteana (Hiern.) F. White 247
Diplopappus asper 5
Disparago ericoides 9, 14
Dobrowskya scabra 14
Drosanthemum crassum L.Bol. .. **335**
Drosera cuneifolia 14
Duvalia polita N.E.Br. 300

Eberlanzia persistens 126
Echidnopsis ballyi (Marnier-Lapostolle) Bally 197
,, squamulata (Dcne) Bally 197
,, urceolata Bally .. 197
,, watsonii Bally .. 197
Ehrharta calycina Sm. .. 250, 255
,, erecta Lam. .. 250, 253
Elyonurus argenteus Nees. 9, 247, 249
Elytropappus rhinocerotis Less. 35, 250, 254
Encephalartos cycadifolius Lehm. .. 248
Eragrostis capensis (Thunb.) Trin. 5, 9, 249, 255
,, chloramelas Steud. 247, 255

PAGE

Eragrostis curvula (Schrad.) Nees. 9, 14, 247
,, lehmanniana Nees. .. 247
,, racemosa (Thunb.) Steud. .. 249,255
,, obtusa Munro ex Fic. et Hiern. 247
Erica cerinthoides 6, 7
,, chamissonis 2, 5–7, 10, 13–15, 22, 29, 35, 38
,, coacervata H. A. Baker **238**, 240, 241
,, demissa 2, 5, 6, 10, 11, 13–15, 17, 18, 20, 22, 29, 34, 35, 38
,, glumaeflora 6
,, schlechteri Bol. 250
,, spp. 11
,, unicolor 238
,, viridiflora Andr. .. 237, 239
Eriospermum sp. 255
Euclea coriacea A. DC. 252
,, crispa var. crispa (Thunb.) Guerke 247, 252
,, crispa var. crispa de Winter 247
Eulalia villosa 9
Euphorbia confinalis R. A. Dyer 173, 176
,, confinalis R. A. Dyer ssp. confinalis .. 173, 175
* ,, confinalis R. A. Dyer ssp. rhodesiaca Leach **174**, 176
,, cooperi N.E. Br. 173, 175
,, grandidens 175
,, graniticola Leach .. 179
,, ingens Meyer 175
* ,, ramulosa Leach **176**, 177, 179
,, schinzii Pax .. 176, 177
,, striata 10, 31
,, tetracanthoides Pax .. 177
,, triangularis Desf. .. 175
Euryops brevipappus M. D. Henderson 254, 255

Faurea magnaughtonii Phillips 78, 84
Festuca caprina Nees. .. 250, 255
,, costata Nees. 252
,, scabra Vahl. .. 250, 252
Ficinia spp. 9, 14
Fimbristylis complanata (Retz.) Link. 133, 137, 142
Fimbristylis complanata
,, Link. var. kraussiana 137
* ,, hygrophila Gordon-Gray **129**, 132–134, 137, 139, 142
,, microcarya F. v. M. 142
,, monostachyos (L.) Hassk. 133, 134, 141, 142, 147, 150–152

PAGE

*Fimbristylis triflora (L.) K. Schum. 133, 134, 141, 142, 147, 150–152
,, triflora var. capitata 152
,, tristachya Thwaits .. 147
* ,, variegata Gordon-Gray 129, **134**, 137, 140, 142

Galium capense (Thunb.) 253
,, rotundifolium L. .. 253, 255
Gazania longiscapa 9
Geranium harveyi Brig. 253
,, ornithopodum E. & Z. 253, 255
Gerbera piloselloides .. 9, 14
,, spp. 6
,, viridifolia 5, 9, 14
Gibbaeum haagei Schwant. var. parviflorum L.Bol. .. **128**
Gladiolus permeabilis de la Roche 251
Gnidia sericea 10
Graderia scabra 8, 21
Grewia occidentalis L. 248
Gymnosporia angularis 14

*Haemanthus canaliculatus 73, 74, **75**
,, rotundifolius 73
Hakea spp. 33
Halleria lucida L. 248, 252
Haplocarpha lyrata 14
,, scaposa 14
Harpechloa falx (L.) O. Ktze 9, 255
Helichrysum anomalum .. 9, 14
,, appendiculatum 5, 9, 14
,, capillaceum Less. .. 251
,, chionosphaerum DC. 251
,, dregeanum Harv. & Sond. 251
,, felinum .. 5, 9, 14
,, fulgidum Willd. .. 255
,, glomeratum 31
,, miconeaefolium DC. 251
,, nudifolium 9, 11, 14
,, petiolatum 14
,, subglomeratum Less. 9, 14, 31, 34, 251
,, trichineatum DC. .. 254
,, triclineatum DC. 251, 254
Helictotrichon longifolium (Nees.) Schweickerdt .. 250
Hermannia flammea .. 5, 14
Heteromorpha trifoliata Wendl. .. 252
Heteropogon contortus (L.) Beauv. 247
Hibiscus aethiopicus .. 10, 14, 21
Huernia bicampanulata Verdoorn 41, 43, 45, 46

PAGE

*Huernia hislopii Turrill 41, 42, 45, 51, 55, 57–59
* ,, hislopii ssp. hislopii 51, 55
* ,, hislopii ssp. robusta 41, 42, 45, **53**, 55
* ,, kirkii N. E. Brown 41–43, 45, 51, 55, 57
* ,, longituba N. E. Brown 41–43, 45, 46, 49, 55
* ,, longituba ssp. cashelensis 42, 43, 48, **49**
,, longituba ssp. longituba 46, 49
* ,, occulta 43, **57**, 58
,, scabra 51
Hypericum lalandii 14
Hypoxis obliqua 5, 9, 14

Indigofera hilaris 6, 11
,, poliotes 14
,, spp. 10, 14
,, stricta 11

Jensenobotrya lossowiana Herre 201
,, vanheerdei L.Bol. **201**, 234

Kiggelaria africana L. 252, 253, 255
Kniphofia africana L. 252, 254, 255
,, uvaria 73
Koelaria cristata (L.) Pers. 250, 255

Lampranthus antonii L.Bol. ..**232**
,, gracilipes (L.Bol.) N.E.Br. forma luxurians 232
,, mucronatus L.Bol. .. **201**
,, prominulum (L.Bol.) L.Bol. 127
,, proximus L.Bol. .. **127**
Lasiochloa longifolia (Schad.) Kunth. 250
Lathyrus odoratus 219
Leonotis leonurus 8
Leucadendron adscendens R. Br. 78, 347–375
,, argenteum R. Br. 78, 370, 371, 373
,, concinnum R. Br. .. 78
,, daphnoides Meisn... 78
,, decorum R. Br. .. 78
,, discolor Buek. .. 78
,, grandiflorum R. Br. 78
,, salignum R. Br. 6, 7, 78
,, seriocephalum Schlechter .. 78
Leucosidea sericea E. & Z. .. 249
Leucospermum attenuatum R. Br... 78
,, candicans Loud. .. 78
,, catherinae Compton 78

PAGE

Leucospermum conocarpum R. Br. 78, 371
,, lineare R. Br. .. 78
,, muirii Phillips .. 78
,, nutans R. Br. 78, 291, 292–294, 296
,, oleaefolium R. Br. 78
,, patersonii Phillips 78
,, prostratum Stapf. .. 78
,, reflexum Buek. .. 78
Linum thunbergii E. & Z. 253
*Lithops aucampiae L. Bol. .. 312
* ,, helmutii L. Bol. 307
* ,, leslei 309, 312
* ,, turbiniformis 306
Lobelia tomentosa 14
Lolium perenne 183, 219

Matthiola incana 219
Maytenus cymosus 247
Melica decumbens Thunb. 253
,, racemosa Thunb. 247
Melolobium calycinum Benth. .. 247
,, microphyllum E. & Z. 251
Metalasia gnaphalodes 6–9
,, muricata 6, 7, 10, 14, 31
Mesembryanthemum abyssinicum.. 209
,, asperulum .. 209
,, brunnthaleri 209
,, cooperi .. 209
,, crassuloides .. 209
,, cronemeyerianum .. 209
,, echinatum .. 209
,, ecklonis .. 209
,, incomptum .. 209
,, jugiferum N.E. Br... .. 206
,, lehmannii .. 209
,, litorale .. 209
,, mahonii .. 209
,, nakurense .. 209
,, nubigenum .. 209
,, oehleri .. 209
,, subincanum .. 209
,, sutherlandii .. 209
,, testaceum .. 209
Microchloa caffra Ness. 255
Mimetes lyrigera Knight .. 78, 84
Monilaria brevifolia L.Bol. .. 126
Montinia caryophyllacea 6
Myosotis sylvatica Hoffm. 251
Myrsine africana L. .. 31, 248

Nemesia capensis (Thunb.) Ktze. .. 253
Nicotiana sylvestris X N. tomentosaiformis 269

PAGE

Ochna atropurpurea 14
conjunctum (L.Bol.) L.Bol. **128**
Oldenburgia arbuscula 27
Oldenlandia amatymbica 14
,, africana Mill. 248, 249
Ornithogalum conicum Jacq. 211, 212, 215, 223, 261, 263, 264, 269, 271
,, flavissimum Jacq. 261, 263, 264, 271
*,, lacteum Jacq. 211,212, 215, 219, 221, 224–226, 261, 263, 264, 271, 325, 326, 330, 332
,, leptophyllum Bak. .. 251
*,, thyrsoides Jacq. 211, 212, 215, 222, 223, 263–265, 269, 271, 325, 326, 330, 332
Osteospermum caulescens Harv. .. 251
Oxalis smithiana 14
,, spp. 10, 14, 20

Panicum perlaxum 9, 14
Paranomus crithmifolia R. Br. .. 78
,, reflexa Phillips & Hutchinson 78
Passerina montana Thod. 250, 254, 257–259
,, sp. 250
Pavetta capensis (Houtt.) Brem. .. 248
Pelargonium leucophyllum Turcz. .. 253
,, sp. 253
Pellea quadripinnata (Forsk.) Prantl. 253
Pentachistis augustifolia .. 9, 14
,, setifolia (Thunb.) McClean 255
,, sp. 255
Pentzia cooperi 257
Phleum pratense 316
Phylica axillaris .. 6–8, 10, 11, 13
Pimpinella schlechteri 14
Pinus pinaster 14
,, spp. 9
Poa binata Nees. 5, 253
Polemannia grossulariaefolia E. & Z. 252
Polygala hispida 10
,, serpentaria E. & Z. .. 253
Polystichum lucidum (Burn.) Bech. 253
Protea acaulis Thunb. 78
,, arborea Houtt. 78
,, barbigera Meisn. 78, 291, 292, 293, 294, 296
,, cedromontana Schlechtr. .. 78

PAGE

Protea compacta R. Br. 78
,, cordata Thunb. 78
,, cynaroides Linn. 78, 291, 292, 293, 294, 296, 371
,, elliottii 370
,, eximia (Salisb. ex Knight) Fourc. 78, 291, 292, 293–296
,, grandiceps Tratt. 78, 291, 292–294, 296
,, grandiflora 370
,, incompta R. Br. 78
,, lanceolata E. Mey. .. 78
,, latifolia R. Br. .. 78, 292
,, laurifolia Thunb. 78
,, lepidocarpodendron .. 370
,, longiflora Lam. 78
,, nana Thunb. 78
,, mellifera Thunb. 348
,, neriifolia R. Br. 78
,, obtusifolia Buek. 78
,, odorata Thunb. 78
,, pulchella 371
,, repens (Linn.) Linn. non Thunb. .. 78, 347–377
,, scolymocephala Reichard .. 78
,, susannae Phillips 78
Psoralea pinnata 6, 10
,, polyphylla 24
,, spicata 6, 14, 31
Pteridium aquilinum .. 9, 14

Rapanea melanophloeos 28
Relhania pungens L'Herit. .. 250, 254
Restio triticeus .. 5, 8, 9, 13, 14
Rhamnus prinoides (L.) L'Herit. 248, 252
Rhoicissus microphylla (Turcz.) Gilg. & Brandt .. 255
Rhus dentata Thunb. 252
,, divaricata E. & Z. 252
,, eckloniana 14
,, erosa Thunb. 248
,, fastigiata 12, 14, 29
,, glauca Desf. 248, 252
Rhynchosia totta 14
Royena pubescens 14
Ruschia conjuncta L.Bol. 128
,, densiflora L.Bol. **202**
,, lisabeliae L.Bol. **125**

Satyrium membranaceum 14
Scabiosa anthemifolia 14
,, columbaria L. 251
,, spp. 5, 8, 10
Schoenoxiphium sparteum .. 9, 14
,, sp. 255
Scolopia mundii (E. & Z.) Warb. .. 247
,, zeyheri (Nees.) Harv. .. 248

PAGE

Sebaea macrostigma 5
Selaginella njamnjamensis Hieron. 179
Selago brevifolia Rolfe 255
,, corymbosa .. 2, 5, 6, 10, 11, 37
Senecio asperulus DC. 255
,, concolor .. 4, 5, 8, 10, 11, 14
,, hieracioides DC. 251
,, isatideus DC. 251
,, juniperus L. 251
,, othonnaeflorus .. 5, 10, 14
,, pterophorus .. 10, 11
Serruria artemisaefolia Knight .. 78
,, burmanni R. Br. 78
,, florida Knight 78
Setaria flabellata 9, 11, 14
,, lindenbergiana (Nees.) Stapf. 248
,, sphacelata (Schum.) Stapf. & Hubbard 313, 314, 317, 319 323
Silene burchellii Otth. .. 253, 255
,, capensis Otth. 253
Stapelia semota N.E. Br. 300
Stapeliopsis neronis Pillans .. 195–198
* ,, urnaeflora Lavranos **195,** 196, 198, 199
Stoeberia carpiana Fridr. 234
Sphalmanthus rejuvenalis L.Bol. .. **125**
Sporobolus capensis 9
,, fimbriatus Nees. .. 247
,, subtilis Kunth... .. 133
Streptocarpus angustilobus N.E.Br. 118
,, baudertii L. L. Britten 94, 123
,, bolusii 274
,, breviflos .. 153, 162
,, bullatus 274
,, çandidus O. M. Hilliard 273, 274, 280, 285, 286, 290
,, compressus 96
,, comptonii Mansfeld 101, 102
,, confusus Hilliard 96–98, **115**–118, 121–123, 160
,, cooksonii B. L. Burtt. 94, 102, 154
,, cooperi C.B.Cl. 153, 155, 157, 160–162, 167, 170
,, cyaneus S. Moore 90, 91, 285, 286
,, daviesii N.E.Br. ex C.B.Cl. 96, 97, 111–113, 123
* ,, davyi S. Moore 90, 273, 274, 286, 287, 290
,, denticulatus Turrill .. 95
,, dunnii Hook.f. 90, 91, 94, 95

PAGE

*Streptocarpus fanniniae Harv. ex C.B.Cl. 88, 92, 94, 273–275, 278, 280, 282–284, 286, 290
,, fannineae var. β minor 275
,, galpinii Hook.f. 90, 91
,, gardenii Hook. 88, 91, 160, 168, 282, 284
,, gracilis Burtt. .. 106
,, grandis N.E.Br. 91, 94, 117, 118, 153–157, 159, 160–162, 163, 168–170
* ,, haygarthii N.E.Br. ex C.B.Cl. 91, 95–97, 104, 109, 113, 115–123, 156, 157, 160
,, johannis L. L. Britten 90, 94, 123
,, luteus C.B.Cl. .. 286
,, micranthus C.B.Cl... 94
,, molweniensis Hilliard 153–155, 159, 160, 162, **163**, 165, 167, 168
,, muddii C.B.Cl. .. 284
,, pentherianus Fritsch 88, 91, 96–98, 107, 112, 113, 115, 123, 287
,, pole-evansii Verdoorn 94, 95
,, polyanthus Hook. 87, 92, 94, 96–98, 102, 103, 105, 109, 123
,, polyanthus ssp. comptonii (Mansfeld) Hilliard 96, **101,** 104, 115
,, polyanthus ssp. dracomontanus Hilliard 96, **101,** 103, 104
,, polyanthus ssp. polyanthus 96, 100, 102, 104, 120
,, polyanthus ssp. verecundus 96, **100,** 102–104, 109, 117, 121, 122, 162, 166
,, porphyrostachys Hilliard 153–155, 159, **169,** 170
,, primulifolius Gandoger .. 90, 170
,, prolixus C.B.Cl. 96, 97, 102, 105, 107, 109, 111, 123, 162
,, pusillus Harv. ex C.B.Cl. 88, 90, 115, 273, 274, 287, 290
,, reynoldsii Verdoorn 118, 120, 157
,, rexii (Lindl.) Hook. 90, 92, 94

PAGE

Streptocarpus rimicola 274
,, saundersii Hook. 153, 154, 155, 159, 161–163, 165, 167–170
,, saundersii Hook. var. breviflos C.B.Cl. .. 161
,, silvaticus Hilliard 96, 97, 107, **109**, 111, 112, 123
,, solenanthus C.B.Cl. 157
,, tubiflos C.B.Cl. 155, 162, 166
,, vandeleurii Bak.f. et S. Moore 92
,, wendlandii Sprenger 153–155, 159, 162, 165, 166–168
,, wilmsii Engl. 273, 274, 280, 284–286, 290
,, woodsii C.B.Cl. 275, 280, 284
Struthiola argentea 6
,, macowani 14
,, parviflora .. 10,14
Sutera ? floribunda 251

Tarchonanthus camphoratus 4, 28
Tephorsia capensis 10, 11
,, grandiflora 14
Themeda triandra 5, 8, 9, 11, 13, 14, 20, 247

PAGE

Thesium imbricatum Thunb. .. 250
,, junceum 14
,, spp... 10
Thunbergia alata 14
Trachyandra saltii (Bak.) Oberm. .. 251
Trachypogon spicatus (L.f.) O. Ktze. 250, 251
Trichodiadema attonsum 203
,, barbatum 203
,, densum 203
,, fergusoniae .. 203
,, intonsum 203
,, pygmaeum L.Bol. .. **335**
,, pomeridianum .. 203
,, setuliferum 203
,, strumosum .. 203
Trifolium burchellianum Ser. .. 251
Trimeria trinervis Harv. 247
Tristachya hispida (L.f.) K. Schum. 9, 249, 255
Tulbaghia alliacea 5

Ursinia anethoides 6, 10, 11, 13

Valeriana capensis 253
Vellozia spp. 179

Woodsia burgessiana Genr. 253, 255

SERVICE PRODUCTS
DIENSPRODUKTE (PRETORIA)
CALEDON STREET
[illegible]